Stable Hybrid Screening with Enhanced Dot Growth Control in Highlights and Shadows

Rudi Bartels, Dirk Vansteenkiste*

Keywords: screening, dot, CTP, film, printability

Abstract: When AM screening techniques are used for rendering very bright tones the resulting halftone dots can become too small to be reproduced effectively. An algorithm is proposed to generate hybrid (e.g., stochastic and conventional) halftone tiles with enhanced dot growth control that guarantees stable halftone rendering in highlights and shadows. The proposed method was tested on different CTP device in a wide range of line rulings and is shown to produce a more repeatable and stable process.

Introduction

Most reproduction devices are not capable of reproducing a continuous range of tones. They can either print ink or not. Several techniques are developed to simulate continuous tones on this type of devices. Those simulated continuous tones are called halftones. Halftones are obtained by printing more or less black points in the same area on paper. A distinction can be made between two major classes of methods for distributing a given number of dots over the area. FM screening, stochastic screening or dot-dispersed screening tries to spread the printed dots as homogeneously as possible over the surface. AM screening or dot-clustered screening will group single printed dots together in larger dots. The darker the image is, the bigger those dots will be. FM screening has the advantage over AM screening that it better can render the high frequencies in the image. The lower frequencies on the other hand will be rendered more noisely by FM screening. To ensure that AM screens render higher frequencies better, higher line rulings can be used. A problem here however arises at the highlights and shadows. A tone is rendered by putting a fixed number of dots, all of the same size, in a given area of paper. The bigger this fixed number is, the

* Both Agfa Gevaert N.V.

smaller those dots will be. For very high line rulings those dots will be that small in the highlights that they will not print. As result of this the very bright tones will be clipped which leads to burned out images and fake contours.

Figure 1: When the original image (top left) is rendered with a high line ruling the cyan plane (top right) will be clipped (bottom left) what will result in fake contours in de rendered image (bottom right).

This is shown in figure 1. The original picture is seen at the top left. The cyan plane is seen at the right. When this image is rendered the cyan in the skin tones will be clipped. Instead of the picture at the top right, the cyan plane will rather be the picture bottom left. An idea of how the image might look like is shown at the bottom right picture.

You can easily calculate what the clipping percentage is. Let's assume we have a screen at 1270 dpi, a line ruling of 180 lpi and you need at least a square 40μ dot to get a reproducible dot. The clipping percentage will be:

$$\% = 100 * 4 * (dpi/lpi)^2 = 8\%$$

Hence every cyan percentage below the 8% will be clipped. And that's indeed what we got when we tried a high line ruling Agfa Balanced Screen on a newspaper 2 years ago. Al tones below the 8% were clipped giving us the fake contours in images like shown in figure 1.

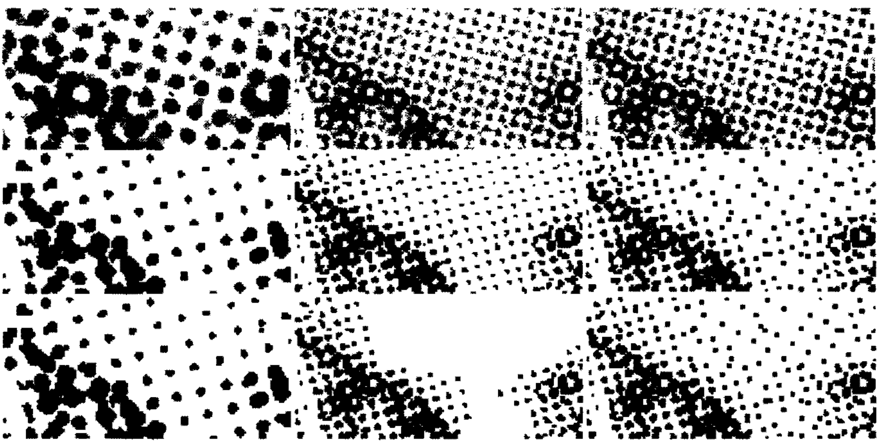


Figure 2. Comparison of a low frequency AM screen (left column), a high frequency AM screen (middle column) and a high frequency Hybrid screen. The top row shows the CMYK image with the rosettes. The middle row is the theoretical cyan plane. The bottom row is the cyan plane that actually will show on print. As can seen in the middle column, the high frequent AM screen will lose all it's small dots. The high frequency Hybrid screen however still prints dots in the bright tones.

Hybrid screening is a new type of screening that will be able to render an AM screen with high line ruling without loosing highlights and shadows. The principle is very simple. In the midtones you have a normal high frequency AM screen. When tones become brighter, dots become smaller. But you let dots only get smaller till a certain limit. When the dots have the size of the smallest reproducible dot you don't let them go smaller anymore. In stead you take entire dots out of the AM grid. From this moment on you don't have an AM screen anymore. You are not modifying the amplitude but the number of dots or the frequency. So you have a FM Screen. The same applies for the shadows. That's why this type of screening is called Hybrid screening. In the midtones you have AM in highlights and shadows you have FM.

Figure 2 shows a microscopic image of a low frequent conventional AM screen, a high frequent conventional AM screen and a high frequent hybrid screen. As can seen in the middle column will the theoretical cyan plane (middle row) be clipped and look like the image at the bottom. Because the hybrid screen put fewer but larger dots no clipping occurs (right column).

Finding the minimum reproducible dot

The first step in generating stable hybrid screens is determining which dots are still printable. We tried several test charts to test this. In a first chart (figure 3) we compared different dot shapes of increasing size as well as the reproduction of vertical and horizontal lines.

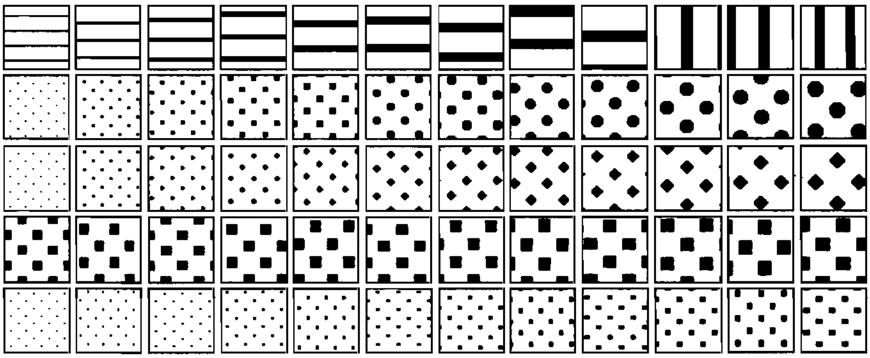


Figure 3. First dot replication test chart. Reproduction of different dot shapes, horizontal and vertical can be checked with it.

Because of the small size of the dots (2x2, 3x3, 4x4,...), there is only a very small difference between the shape of a circle, a diamond or a square. So row 3 and 4 are not very useful. Also knowing how lines are being reproduced is not needed for the design of our hybrid screens.

When looking carefully to the bottom two lines one can see that not all dots are squares. Some of them are rectangular. The sizes are as follows: 1x1, 1x2, 2x1, 2x2, 2x3, 3x2, 3x3, 3x4, 4x3, 4x4, ... The reason for this is that we wanted to test if there was a difference between the slow scan or the fast scan direction. And indeed for some devices a 1x2 dot will perfectly hold on plate and print, while a 1x1 or a 2x1 disappears. This is due to the fact that the writing laser beam can't be shut on or off immediately resulting in a softer edge and smaller dot in the fast scan direction. Making asymmetrical screens however, can be very dangerous. The rip doesn't always know when it's rendering the bitmap, in what direction the image is going to be placed on plate. It might be that the imposition software or the device driver rotates the bitmap over 90°. This would result in an unexpected dot loss and a hybrid screen not performing better than a conventional AM screen.

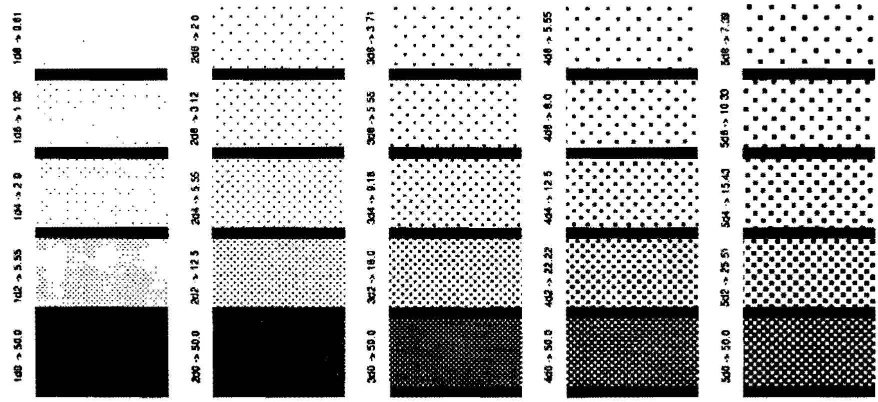


Figure 4. Second dot replication test chart. In the vertical direction the size of the square dots is increased. From bottom to top the number of spare lines between the square dots is modified.

Because of all this we made a second chart that only consists of square dots (figure 4). The size of the dots increases from left to right. From top to bottom the average distance between the dots is altered. Because of the chemical nature of the whole process it might be that a dot perfectly holds on plate when other stable dots are in the neighborhood, but that the dots disappears when it is isolated. The numbers next to the chart are formatted as follows:

x d y -> z

with x the size of the square dot

y the number of spare lines between the square dots

z the theoretical dot area of the bitmap

With this chart we can see till what percentage a dot still holds on plate. If one wants to have guaranteed printing till 1% he can check if the chosen dot size will perform as requested.

All what is told for the above holds for the highlights. The charts used for testing contained a similar part for the shadows. So we could see what 'hole' size is needed to keep the prints open.

Key	Description
Gal Therm	Agfa Galileo T CTP device with thermal plates, resolution 2400 dpi
Gal Litho	Agfa Galileo VXT CTP device with silver based plates and violet laser, resolution 2400 dpi
Gal N91	Agfa Galileo CTP device with photo polymer plate, resolution 2400 dpi
Phoe All Pos	Agfa Phoenix CTF device with Agfa Alliance film, positive workflow, resolution 2400 dpi
Phoe All Neg	Agfa Phoenix CTF device with Agfa Alliance film, negative workflow, resolution 2400 dpi
Phoe Im Pos	Agfa Phoenix CTF device with Agfa Impower film, positive workflow, resolution 2400 dpi
Phoe Im Neg	Agfa Phoenix CTF device with Agfa Impower film, negative workflow, resolution 2400 dpi
Pol Lith	Agfa Polaris CTP device with silver based plates, newspaper, resolution 1270 dpi
Pol Therm	Agfa Polaris CTP device with photo polymer plate, newspaper, resolution 1270 dpi

Table 1. Overview of Agfa imagers on which dot replication was tested.

We tested this for different Agfa imagers. Table 1 gives an overview of the different Agfa engines we tested on. Table 2 shows the results of the dot replication test guaranteeing a 1% will print and a 98% remains open.

Key	Min. Highlight Dot	Min. Shadow Hole
Gal Therm	2x2	3x3
Gal Litho	2x2	3x3
Gal N91	2x2	3x3
Phoe All Pos	3x3	2x2
Phoe All Neg	2x2	3x3
Phoe Imp Pos	3x3	2x2
Phoe Imp Neg	2x2	3x3
Pol Lith	2x2	3x3
Pol Therm	2x2	4x4

Table2. Results of the dot replication test guaranteeing a 1% will print and a 98% remains open.

Besides the guaranteed dot in the hybrid screen by switching on a number of raster elements simultaneously we also implemented an extended dot growth control when growing the small dots. Especially with small dots at the limit of reproducibility it is important to let the dot grow in a very stable way.

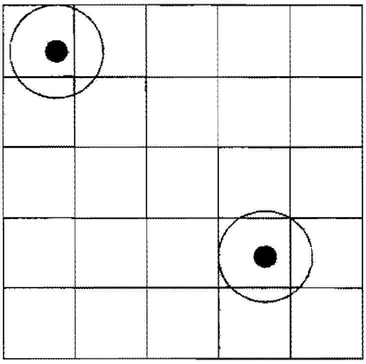


Figure 5. Depending on the location of the theoretical dot center and used spot function the dot shape can be either a stable dot (top right) or rather unstable (bottom left)

The way how a dot grows depends on the spot function used for the tile and the theoretical (floating point) center of the dot. This is shown in figure 5. The theoretical center of the top left dot is positioned in respect to the grid in such a way the dot grows to a 2x2 square. The dot center of the bottom right dot however makes the dot grow as a cross. Especially in flexography the latter will be less stable. Special dot grow control techniques are embedded in the screen generation algorithms to increase the stability of the rendered AM dots.

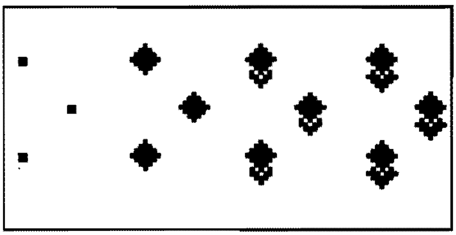


Figure 6. It is possible to control the dot growth in such a way the dots grow to small Taga logos.

Figure 6 shows an example of how those techniques can force the dot to grow in a very specific way. The dot starts as a 2 by 2 and after this grows in such a way that at 18 % a very small version of the Taga logo is obtained at every dot position.

Tile Replication Risk

Many devices interact with the computer via a Postscript™ interface. In order to handle high resolutions Postscript™ is equipped with a tile based mechanism that can render a continuous tone image into a halftone matrix in a very effective way. A tile is a set of thresholds to which the continuous tone values of the image are compared [1]. If the continuous tone value is smaller than the threshold, the pixel is made black. In the other case the pixel remains white. This tile is repeated in the horizontal and the vertical direction so that the whole image is covered (figure 7).

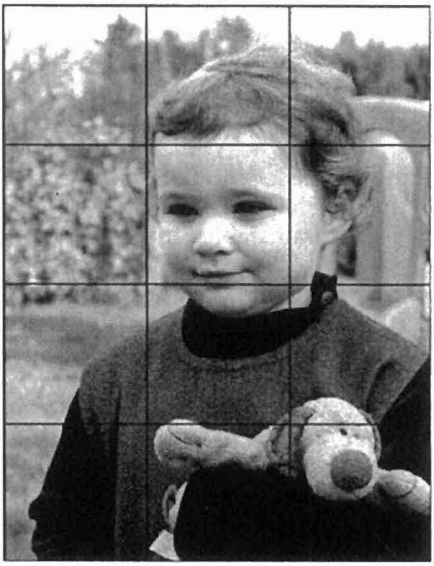


Figure 7. A tile (mask) with threshold values is placed over the image and repeated in horizontal and vertical direction allowing a very fast rendering.

When designing a tile one should care that the next expected row of the bottom row is the top row and the next expected column for the right column is the left column. When repeating the tile over the image the seam should not be visible.

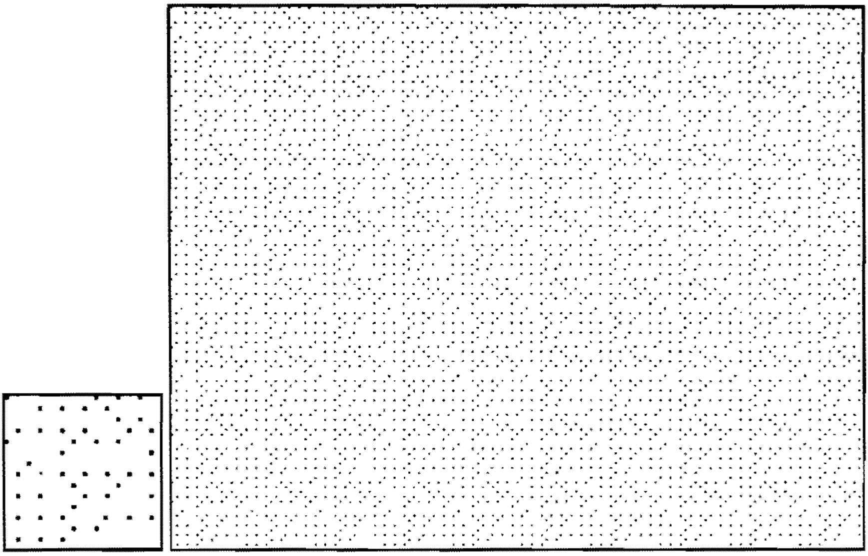


Figure 8. When the tile is badly designed a strong pattern may appear when rendering a constant tone.

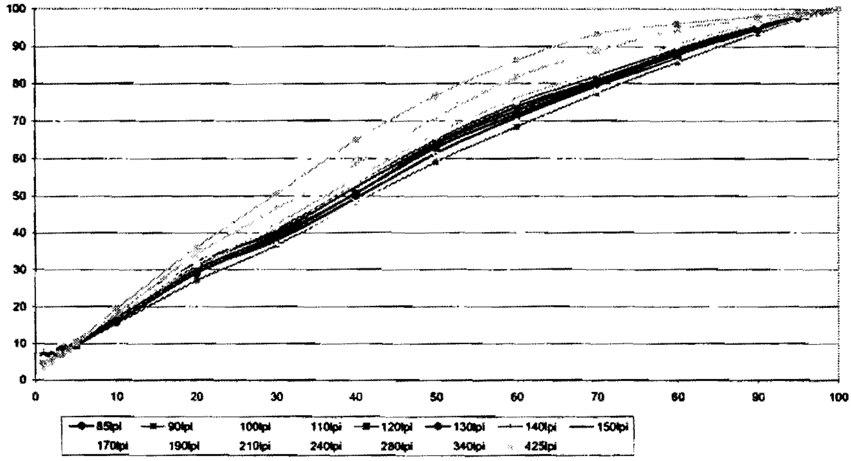
For the AM-part of hybrid screens the parameters are carefully designed in such a way that the seem is not visible. For the FM-part an extra difficulty arises because dots are placed in a random order making always some unbalance that will cause a pattern when repeated in horizontal and vertical direction. This is shown in figure 8. If the tile (left image) is used to render a flat tone the rendered image might look like the right image.

By use of special algorithms to determine the order in which dots are to be withdrawn, by selecting a proper tile size and adding positional noise those patterns can be made less visible. [2] gives a detailed description of how this can be done.

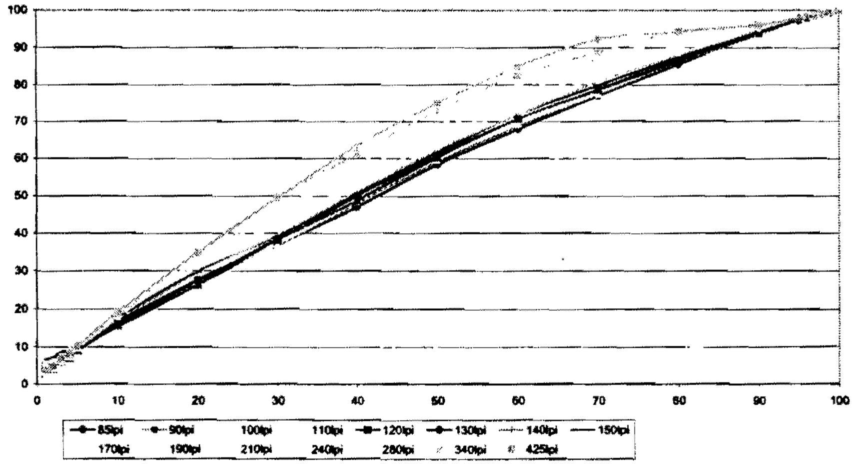
Printing results

For all Agfa imagers extended tests are carried out. Here some results are shown. In graph 1 and 2 prints made in Europe are compared to prints made in the US. Graph 3 and 4 show the difference between fresh and steady chemicals. Graph 5 shows compares Agfa's Impower Plus to Aliance film.

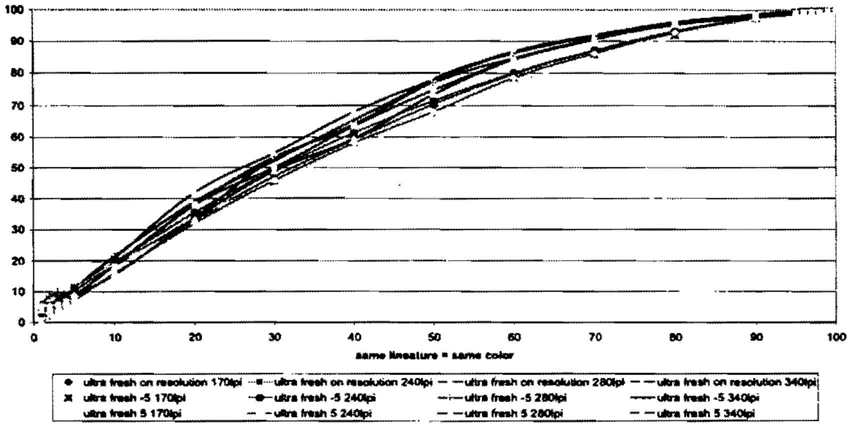
As can seen in all graphs higher line rulings result in higher dotgains. But in all cases the curves don't show any clipping. Even for the highest line ruling the low percentages remain on print.



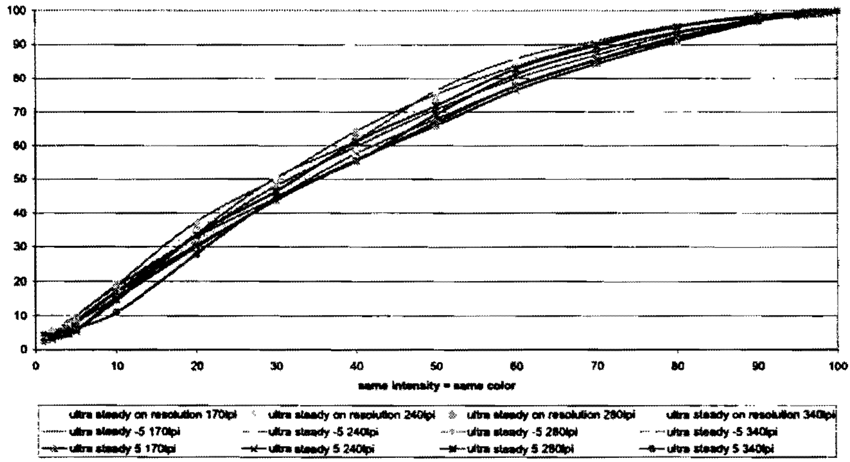
Graph 1. Dotgain curves of screens obtained by plates made on a thermal Galileo and printed in Europe.



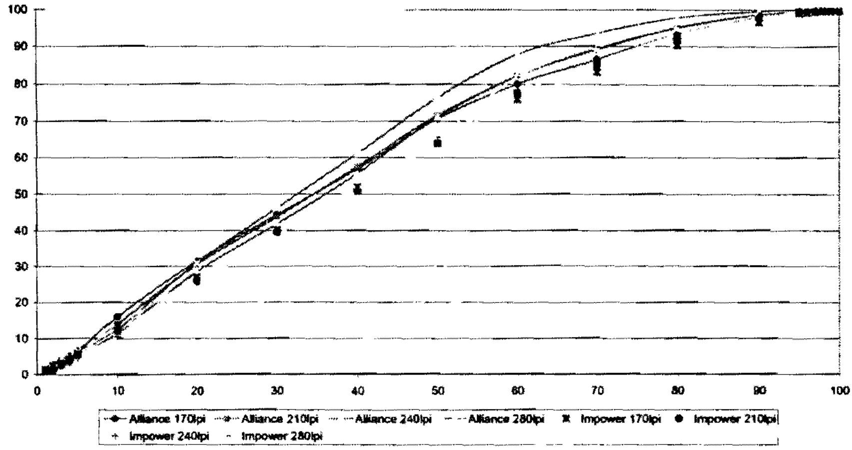
Graph 2. Dotgain curves of screens obtained by plates made on a thermal Galileo and printed in the United States.



Graph 3. Dotgain curves of screens obtained by silver based plates made on a Galileo VXT with frech chemicals.



Graph 4. Dotgain curves of screens obtained by silver based plates made on a Galileo VXT with steady chemicals.



Graph 5. Dotgain curves of screens obtained by CTF. Both Agfa film types Impower Plus and Aliance are imaged on a Phoenix image setter.

Conclusion

In this paper is stated how hybrid screens can tackle the clipping problem in conventional AM-screening with very high line rulings. An overview is given of how the minimum reproducible dot can be determined and how dot growth control can result in more stable dots.

Some results of the extended testing of Agfa's hybrid screening on different engines are shown. Even with very high line rulings no clipping occurs.

Recently Agfa released hybrid screens for all engines. The techniques described in this paper made it possible for example to use screens up to 180 lpi for newspaper. Extended beta testing have proven the applicability of this screen for more than one year in a Swedish newspaper.

Reference List

[1] Adobe Systems Inc., "PostScript L.nguage Reference, third edition", Addison Wessley (1999).

[2] Rudi Bartels, "Reducing patterns in the FM Part of tile-based hybrid screens", IS&T's 2002 PICS Conference, p241 – p244.

[3] Paul Delabastita, "Screening techniques, Moiré in Four Color Printing", TAGA, 1992 Proceeding's, Vol.1.

[4] B. E. Bayer, "An optimum method for two-level rendition of continuous-tone pictures," Proc. IEEE Int. Conf. Commum., pp. 2611-2615. (1973).

[5] R. Ulichney, "Digital Halftoning"., MIT Press, MA, 1987.