A Screenless Electronic Imaging Process Using Frequency Modulation

Gerhard Fischer*

Abstract:

Image Quality is related to the capabilities of the imaging process. An ideal process would allow for the best rendition of detail with a minimum of image distortion by noise. Therefore, the color print would be very similar to collotype.

A noval electronic imaging process is described for approaching the quality of collotype while gaining a very high consistency in printout even with extremely long print runs. The grains of the color separation are electronically generated. The image is frequency modulated in order to ensure rendition of both line art and continous tone with the same process. This process is implemented in high speed electronics.

Results regarding processing speed, printability and image resolution are compared against offset in standard screen rulings.

In general, imaging may be understood as an information transmitting process (Wolf, 1970). For this purpose, optical, opto-electrical, electronic, electro-optical or electrothermal and mechanical transmitters may be utilized for the single transmission steps.

Each one of these transmitters picks up information from it´s source. The original first source is probably a photography. The information will then be processed as received according to the function of the transmitter and passed on to the next receiver. The final receiver is usually the human eye looking at a hardcopy.

At each transmission step, there are signals and there is noise always merged with the signals. Both can never be separated in a meaningful way except with task specific filters.

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* Du Pont de Nemours (Deutschland) GmbH

Looking at hardcopies through a microscope, the surface structure of the paper as well as the agglomeration of ink pigments obviously contain more noise than signal. From a major viewing distance, this noise is probably not visible but some small details may not be visible as well.

As signals our eye receives a lot of details that need to be filtered for understanding. The details of an image seem to have a certain size that we detect from their contrast against the surrounding area. Their color is detected by knowledge and by comparison with other related colors of the image. While human vision is based on knowledge and on education the "readabilty" of images largely depends on the clarity of detail rendition. Distortion of details by noise is different for the various imaging processes (Hradezky, 1977).

Printing directly from grain in the collotype process is well known for excellent rendition of detail. Until today, this process shows less noise in color prints than any other process. Because of the very fine grain particles and because of their random distribution sizes and colors of all image details are precisely reproducible even in spectral accuracy. It is possible to print images in as many colors as adequate for the print job. However, the very fine grain particles are very sensitive. Printing high numbers of copies in major print runs seems to be impossible.

Photographic screens as an alternative produce much coarser printing dots instead of the fine collotype grain. They allow for high numbers of copies in a press run. On the other hand there is a significant loss in detail rendition according to the screen ruling. Moreover, moire in color printout causes additional distortion by moire patterns. Despite of this, photographic screens are sensitive to dust and scratches.

Electronic screening is widely considered sufficient for the graphic arts industry of today. This technology seems to provide both appropriate reproducibility and ease of use while allowing for sufficient flexibility to meet the requirements of image manipulation. However, people concerned with the very highest quality or with color consistency throughout major print runs are well aware of different moire effects. For example, serious limitations regarding detail rendition show up at rescreening jobs in offset-gravure conversion, especially with rendition of textures. As a consequence, there is some interest towards finer screen rulings for better detail resolution. Furthermore, screenless methods are discussed and investigated as an alternative to screening.

Therefore, it is here proposed to utilize electronic equipment for generating grains rather than dots. Grain sizes might be optimized for various printout processes in order to ensure the highest reproducibility. The adaptation of grain sizes would probably further allow to minimize image noise with ink on paper if the grains would be small enough. When distributing them in a random way moire would disappear. Finally, their positions relative to each other could become representative for the tonal value with major distances for light tones and with short distances for dark tones. The tonal rendition may be based on the local frequency of the grains. Utilizing frequency modulation, the resolution of details probably might become totally comparible if not even better than with collotype.

The novel process described in the following is very simple and shows a fundamental similarity to human vision. As previously discussed, human vision is triggered by comparisons for detecting color, size, contrast and so on. Any comparison requires a minimum of two elements to be compared against each other.

Applying this principle to image processing, we easily find that any image area may be devided into partitions to be compared against each other. Further, any partition may be subdivided into subpartions for more detailed comparison. The smallest pair shows only two image elements as detected from scanning.

Each pair may deliver the fundamental criteria that allow for meaningful decisions regarding printout and dot positioning. Important for this application are the questions whether to print or not and at which one of the two elements. If for example both elements show high tonal value at least one of them should be printed. If furthermore the tonal value of element "a" is higher than the tonal value of element "b", obviously element "a" should be printed first. In this example, "a" was selected for being printed with this comparison while "b" will remain open for another comparison. As a consequence, the pairs on low levels always deliver one free element for the next higher level pair. Therefore, each pair can be treated consistently throughout the image area regardless the size of the partition.

In order to represent tonal values precisely a threshold may be utilized (Fischer, Quabeck, 1988). If the tonal value sum of the two elements a and b is higher than the threshold a dot or grain will be printed. The value of the threshold as representing one dot thereafter will be subtracted from the sum. The remaining value together with the printed dot represents this pair for the next comparison. Therfore, the remaining value will be shifted to the element that remains open for the next higher level pair. In case the tonal value sum is below the threshold the sum becomes the remaining value and is as well shifted to the open element.

As a consequence, all printed dots are simply generated by passing a threshold. For example, a major totally dark area with 100 % area coverage would obtain 50 % area coverage from the lowest level pairs, additional 25 % from the next higher level pairs and so on until the whole area would be covered. However, in the special case that all image elements show exactly the same tonal value the decision on where to print first within each pair will be based on another rule or just on noise.

Because of the simplicity of the process high speed electronics like an application specific gate array may be chosen. According to the semiconductor technology the data throughput obtainable will vary from around 15 million up to some 150 million dots or grains to be processed per second. Therefore, the single gate array would allow for producing 2 pages per minute when using the slowest gate array for generating extremely fine grains of 12 microns average diameter. For a high speed application, an average grain size of 30 microns may be adequate and therefore allow for up to 200 or more pages per minute with the fastest gate array technology.

In comparison with screening, the proposed process is much simpler and therefore allowing for much higher process speed. As a major advantage of this process, the same technology may be utilized for so called nonimpact printers (e. g. laser or ink-jet) as well as for offset. Surprisingly, this process provides additional benefits for offset applications.

In offset printing, the consistency of printout is determined by ink splitting as the basis of ink transfer. The rubber cylinder transfers the printing ink from the plate cylinder on to the paper. Between the cylinders the ink is under very high pressure from the cylinders and thereby fixed on both sides with the surfaces at the two cylinders. For example, at the final ink transfer the one surface will be the rubbersheet and the other one will be the paper. When leaving the printing zone of high pressure, the tight contact of the offset ink with both surfaces will remain. Rather than splitting at any surface the ink will be stretched to produce an ink thread which becomes longer and longer while getting thinner and thinner in the center. Finally the ink thread splits somewhere close to the center of the thread (Wagenbauer, 1964).

The process of ink splitting applies to every dot or grain to be printed. For the high pressure printing zone, the dots of an image may be understood as small drops in cylindric shape. The diameter of this cylinder corresponds with the dot or grain size on the printing plate and the hight of this cylinder corresponds with the printout density. Consequently, the volume of the ink cylinders will be determined by the sizes of the dots and the grains.

Dots of constant size may therefore allow for higher consistency in printout whereas dots of different sizes will cause different ink threads. With small dots, the volume of the ink cylinder is accordingly small. The ink thread as generated from scratching the ink cylinder will most likely be short and split directly behind the printing zone. For big dots the length of the ink thread may be much larger according to the much larger ink volume. Consequently these threads will split later, in a less consistent way and the ink may even flow a little bit after splitting. Screen printing typically shows dots with 15 up to more than 60 microns in diameter on smooths papers. On rough papers they are bigger and may well reach a range from a minimum of 25 up to more than 100 microns in diameter.

In collotype prints the grain sizes are much smaller. Some grains are too small for even being measured with a microscope. While most grains are very small there are some big ones in between reaching up to 30 microns in diameter on smooth papers and 50 microns or even more on rough papers.

Frequency modulated images as well show grains rather than dots. Their grain sizes vary only a little bit according to paper roughness and are typically bigger than collotype grains. Therefore, the diameters vary randomly around an average diameter. For tests with various printing maschines and many paper qualities we usually adjusted the grain sizes between 20 microns in diameter for smooth and up to 35 microns in diameter for rough papers.

Resolution of detail is to some degree related to dot sizes. As a general rule, smaller dots allow for finer resolution. However, to a major degree the image modulation process determines the rendition of detail.

In case of the collotype process, very small grains are randomly distributed. Like in any photographic process, there is some loss of resolution caused by the graininess of the process.

In case of the proposed frequency modulated process the positioning of grains as described above is directly related to image data. Details are therefore very precisely represented with a minimum of distortion. For this purpose however, the image original needs to be scanned accordingly, e.g. in a resolution of 50 lines per millimeter when printing with average grain diameters of 20 microns. Similar to collotype furthermore, the positioning of grains causes some graininess, related distortion of details and loss of resolution too. However, the experience so far indicates that the total noise of this process will probably not be higher than with collotype.

Whithin the screening process the resolution is different for all major process steps. Screen ruling (e.g. 50 lines per centimeter) represents only the resolution of the color separation. For producing such a screen, a scanner will usually scan the image original twice as fine, in this case with 100 lines per centimeter. In order to generate all dot shapes required the laser beam of the recorder should have a minimum resolution of ten times the screen ruling. Modern recorders offer even much finer laser beam adressability. When printing a color image however, moire comes up and shows moire patterns which are typically three to four times as coarse as the screen ruling (Morgenstern, 1979). Therefore, the resolution in a screened color printout is strongly limited to less than 20 lines per centimeter.

In Summary, the proposed electronic imaging process as opposed to electronic screening is about twice as fast regarding electronic modulation, better in printout consitency for offset, free from moire and provides about five to ten times higher resolution of detail.

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