Is Error Diffusion FM Screening Becoming a Barrier to High Speed, High Quality, Image Printing?

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Abstract

FM screening has remained the typical choice for high quality image printing on inkjets. The two most common methods of implementing FM screening are error diffusion and stochastic screening. Error diffusion produces excellent quality halftones, but is computationally costly. Stochastic screening has traditionally delivered lower halftone quality, but is computationally cheap and so is much faster. Error diffusion remains the preferred OEM halftoning method in a competitive marketplace where print quality continues to be a product differentiator.

This paper looks at advances in hardware print technology that are resulting in higher resolutions, color depths and much higher print speeds. In these circumstances error diffusion is becoming a print performance bottleneck in certain markets. This limits current devices and may hamper the development of new higher speed devices for high quality printing. Stochastic screening methods meet the performance requirements but need to provide higher quality halftones. A recent advance in stochastic screening is used as an illustration of how such a method can deliver halftone quality comparable to high quality error diffusion, but at much faster speeds.

Introduction

Halftoning is the process of converting continuous-tone images into patterns of printed dots.[1,2] There are two principal halftoning techniques, AM and FM screening, which are illustrated in figures 1 and 2 below.

Figure 1. AM screening

Figure 2. FM screening

As its name suggests, AM screening breaks the image down into dots of varying sizes, at fixed spacing. The result of this is the regular pattern which is AM screening's distinguishing visual signature. In contrast, FM screening keeps the dots the same size and varies their frequency, or number and placement, to simulate the contone image. Visually this results in a pseudo-random placement of dots, which is recognizable from inkjet printer output.

FM Screening

The two most common methods of implementing FM screening are error diffusion and stochastic screening. Error diffusion uses a computationally expensive algorithm at print-time to determine how the dots should be placed. In contrast, with stochastic screening the dot patterns are pre-determined. They are then encoded in a form (a screen) that allows a simple algorithm to be used at print-time to determine which pattern should be used to place the dots.

Stochastic screening's great advantage over error diffusion therefore is that it can achieve much higher data processing performance. However, error diffusion's greater ability to adapt to surrounding pixels leads to superior dot placement and therefore print quality. Historically, low print resolutions, limited colour depths and large dot sizes have meant that excellent dot placement has been required for competitive prints and therefore error diffusion has been the FM screening method favoured by OEMs.

Today's Print Performance Problem

Today, print technology has leapt forward, with high resolutions, small dot sizes and deeper color depths. Error diffusion continues to deliver the most optimal dot placement and therefore print quality. As a result error diffusion has remained the preferred halftoning method by OEMs. However with much higher resolutions and variable dot sizes image data size has inevitably risen at the same rate. This means that error diffusion's high computational cost has had an increasing impact on rendering times. In circumstances where the hardware print speed is not sufficiently high to absorb that rendering time error diffusion can become a performance bottleneck. This limits current devices and may hamper the development of new higher speed devices for high quality printing. This is a particular issue at a time when it is often stated that inkjet printing will inevitably win out against competing digital print technologies due to its lower cost and greater flexibility.

Advances in Stochastic Screening

Stochastic screening methods meet the performance requirements, but as stated earlier do not provide high enough quality halftones due to their inferior dot placement compared to error diffusion. However, today's higher resolutions and smaller dot sizes mean that individual dots are not as visible to the eye as they once were. As a result the bar of what level of dot placement is required to achieve high quality output has lowered slightly. This opens the door to new generations of stochastic screening to improve dot placement sufficiently to achieve print quality that is comparable to error diffusion.[3]

Recent advances in advanced stochastic screening provide excellent dot placement that on today's print technology is comparable in quality to that from error diffusion. Importantly it does so at significantly higher speeds. When profiling the time taken to perform just the halftoning for the render pipeline this particular advanced stochastic screening method has shown to be up to ten times faster than an advanced error diffusion method. Figure 3 shows total print to file times for a variety of document types. As can be seen, the advanced stochastic screening method consistently produces print files at twice the speed of the advanced error diffusion method.

The result of such breakthroughs is that the performance of current printers that are constrained by software rendering times can be improved. More importantly halftone rendering times need no longer limit the hardware design of future printers leading to breakthroughs in print performance. In turn inkjet printers with wide print head arrays can increasingly be applied to high performance production printing environments without compromising print quality, such as production photo printing.

Conclusion

Error diffusion has remained the preferred OEM halftoning method for FM screening where high print quality is required. However the computation complexity of error diffusion combined with the higher specifications of printers today can result in error diffusion becoming a print performance bottleneck in certain markets. This limits current devices and will hamper the development of new higher speed devices for high quality printing. This will be particularly the case where wide inkjet print head arrays are applied to high quality production printing. This paper shows that new advances in stochastic screening methods can deliver halftone quality comparable to high quality error diffusion, but at much faster speeds.

References

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3. Mike Woods, A Dot Placement Approach to Stochastic Screening Using Bitmasks, *Proc. IS&T's NIP20*, pg. 328-332. (2004).

Biography

Stephen Lawrence received his BSc. degree in Computer Science in 1991. He joined Software 2000 (now Software Imaging) in 1992 as a Systems Engineer. Since then, he has engineered systems software that supports the complete gamut of technologies for the worlds leading printer OEMs. He has been Lead Engineer for the PrintMagic™ raster printer Driver Development Kit (DDK) and in recent years the Architect for AutoEZ-Cal™ Software Imaging's color management system. He maintains that responsibility as part of his current role, Product Manager, Colour Technologies.

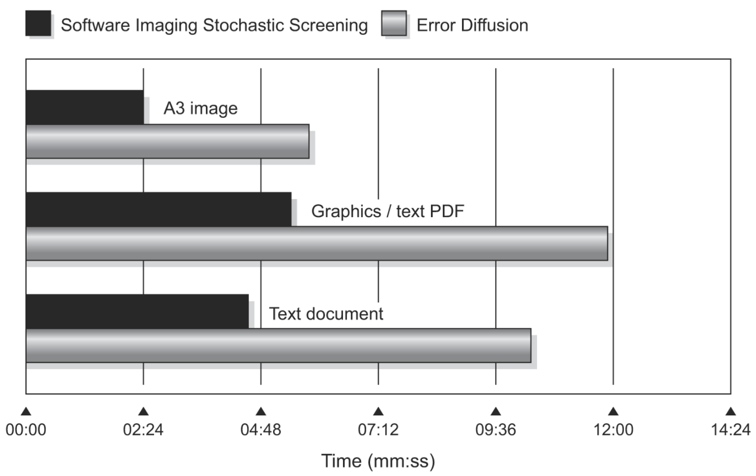

Figure 3.. Print to file timings