Application Note:
Graininess Measurements on Halftones

John C. Briggs (Senior Engineer)
Quality Engineering Associates (QEA), Inc
www.qea.com
Burlington MA/USA

Introduction

To achieve a photo-quality appearance in a printed image, it is important to have very low graininess in the halftones. Being able to quantify the amount of graininess in halftones is helpful to compare different printing techniques, perform QC, and do competitive analysis.

This application note shows how the Personal IAS™ can be used to quantify graininess in halftones. Some inkjet print samples will be used to exemplify the measurement process. However, graininess can be measured on prints produced by any printing method.

Graininess Defined

The term graininess has been borrowed from photography where it is defined as *the character of a photographic image when it appears to be made up of distinguishable particles, or grains*. Today this term is used more broadly to refer to small-scale non-uniformity.

The ISO-13660 International Print Quality Standard defines it as, "Aperiodic fluctuations of density at a spatial frequency greater than 0.4 cycles per millimeter in all directions." The ISO-13660 metric of graininess is the standard deviation of density of a number of small areas that are 42um square.

For more detail, read the ISO standard and the Personal IAS User's Guide.

Setup

To get started in graininess quantification, a test target with a range of halftones must be printed. This can be created easily in bitmap software (e.g. Photoshop) or vector graphic software (e.g. Illustrator) or downloaded from www.qea.com. Typically, the target would consist of a gray tone scale from 0% tint (white) to 100% (black) in 10% steps. Color tone sweeps like cyan, magenta, yellow, red, green, and blue may also be included in the target. For this application note, only the black tone scale will be discussed.

There are a few simple steps involved in setting up for graininess measurement.

1) Use a black "backstop" underneath the test target to prevent the table color from affecting the measurement.
2) Set the Personal IAS to use the Full Size ROI.
3) Use the gray color filter (visual density).

The gray color filter (visual density standard) should be used regardless of what color is being analyzed. Human vision is most sensitive to non-uniformity in luminance (rather than color or chroma). So it is recommended that the gray filter be used for all graininess analysis.

Depending on the sample being measured, it might be desirable to make more than one graininess measurement per patch to reduce errors introduced by sample variability. For the examples given here, graininess in the mid-tone is approximately 6 and only one measurement was acquired for each patch. For samples with lower graininess, consider making multiple measurements and calculating the average reflectance and average graininess values.

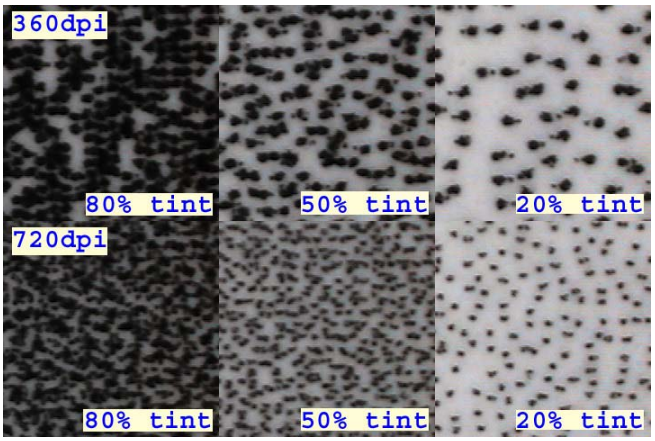

Figure 1: Halftones at two drop sizes. **(1.2×1.2mm images)**

Drop Size Effect on Graininess

Inkjet printers are binary printers, meaning that they can either print a dot at a given location, or not print a dot. That location then becomes either black or white (we will deal with color printers later). The printer cannot create a gray dot.

To create areas that look gray in appearance, inkjet printers create a pattern of black and white (B&W) dots called halftones. These patterns create a non-uniform appearance that can be quantified in terms of graininess.

Inkjet printer manufacturers have developed techniques to reduce the graininess of halftones. One technique is to use smaller drop sizes.

To demonstrate this effect and show how it can be quantified, the following test was performed. Two test targets were printed; one using a 360 dpi print mode and the second printed using 720 dpi print mode. Both prints come from the same printer. As can be readily seen in Figure 1, the 360 dpi print mode uses larger drops than the 720 dpi print mode.

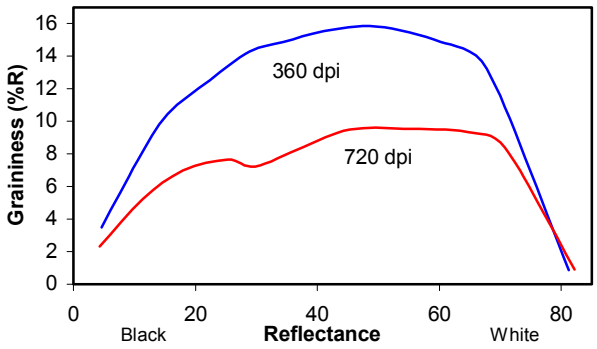

Figure 2: Graininess vs Reflectance for 360 dpi (larger dots) and 720dpi (smaller dots).

The test targets were then measured on the Personal IAS using the *Area* measurement tool. The reflectance and graininess values were recorded, and the results are shown in Figure 2.

The data clearly shows that the mid-tones (20% to 70% reflectance) are the grainiest. The black patches (5% reflectance) and the white patches (80% reflectance) are less grainy. To achieve "photo-quality," inkjet printer manufacturers must work to reduce the graininess in mid-tones.

It is clear from the data, smaller drop size significantly reduces graininess in the mid-tones, see Figure 2. The 360 dpi target has graininess as large as 16 and the 720 dpi target is about half the level at 9. With graininess, smaller numbers are better. This is a significant improvement in graininess both quantitatively (from the Personal IAS data) and subjectively (looking at the prints).

Addition of Colored Drops

Another technique to reduce graininess is to add some colored cyan, magenta, and yellow ink drops into black and white halftones. This helps cover some of the white area of the paper and reduce the graininess of the image. This must be done carefully so that the B&W image does not develop a colorcast in the B&W halftones. Colorcast is frequently a problem for many inkjet printers.

To test this technique for reducing graininess, two test targets were printed. The first target was printed using the black-only mode of the printer and the second target was printed using the color mode of the printer. Once again the targets were measured using the Personal IAS *Area* measurement tool and the reflectance and graininess values recorded.

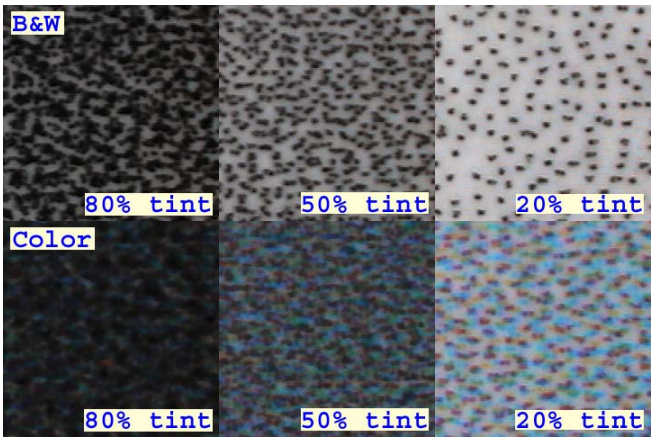

Figure 3: Colored dots into halftones. (1.2×1.2mm images)

The technique is quite effective at reducing the visibility of the white paper, as can be seen in Figure 3 and Figure 4. Using a mixture of colored dots to replace black dots is almost like having light gray ink. Although the colored dots are visible in these magnified images, they are almost invisible to the unaided eye.

The data from the Personal IAS shows that the graininess was reduced from about 9 down to 7, Figure 4. Clearly for the lighter tints, around 60% reflectance, it is difficult to reduce grain even using the colored drops of ink. Nevertheless, this is still a significant improvement.

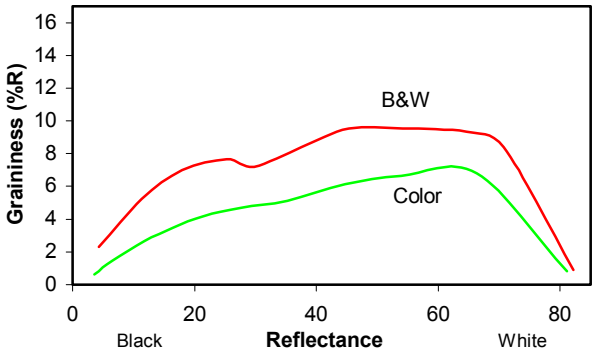

Figure 4: Graininess vs Reflectance for Black and White (B&W) and color halftones.

Hint: When working with graininess data, compare graininess data on patches with similar reflectance values. Don't assume that because two samples have the same tint %, e.g. 50%, that they will have the same reflectance values.