

Studying resolution and contrast

By Franz Sigg

Introduction

How could we measure the differences in resolution between AM and FM screening? How could we measure differences in resolution between a plate setter having an addressability of 2400 spots per inch (spi) and a laser printer that has only 600 spi or a monitor that has only 72 spi?

Addressability and resolution are not the same. Addressability is a measure of the number of spots an output device can place. Resolution is the visual ability to perceive fine structures at various tonal differences between them. There is no single number to specify the resolution of an output device, because resolution is a function of tonal difference (contrast). Moreover, resolution is related to the way that gray levels are produced, in other words, with the type of screening.

Halftones and Gray levels

There are two fundamental ways that gray levels can be produced: 1) Spots can be arranged in variable area clusters (halftone dots); or 2) Each spot can be imaged at variable density (bit depth). Both methods can be combined.

Offset printing can only print either full ink film or none. In this sense it is a binary system, where gray levels are produced by the use of halftone dots that are too small to be seen individually, but cover more or less area to produce different gray levels for the eye. In turn, each halftone cell is made up of the spots from the output device (imagesetter). Many spots are needed to form a halftone cell. This means that spots have to be very small indeed (about 10 microns wide, about 256 per halftone cell).

The spots on a monitor are about 35 times bigger; there are only ca. 72 per inch. Yet, images on a monitor can be very good, because each spot can be imaged at many (256) color intensities for each color channel. The number of gray levels that any spot can have is

called bit depth and is expressed as a binary number. Offset printing has a bit depth of 1, a monitor has a bit depth of 8. Systems like laser or ink jet printers have an intermediate addressability of some 400 to 800 spi and they use a mix of halftone and bit depth modulation to obtain the gray levels.

Resolution and Contrast

The resolution obtainable by these output devices is affected by three kinds of frequencies that interact with one another: 1) Small image detail (pixels), 2) The addressability grid of the output device (spots) and 3) The halftone pattern (dots). To print an image pattern with very high contrast (black and white) does not require a halftone. The image is just formed by turning on or off the spots of the output device. This means that only two frequencies are involved and therefore better resolution is obtainable. This is one example of how resolution depends on contrast.

It is not easy to get quantitative data about resolution from pictorial images. It is much better to reproduce a test pattern that systematically samples different image resolutions at different contrasts. The RIT ConRes test target can be used for the purpose.

Description of Contrast target

The RIT Contrast Resolution Test Target, shown on page 11, consists of 6 panels, two each for cyan, magenta and black. For each color, one is vertical, the other is horizontal. Each panel consists of 10 rows with different line widths (representing image detail), and 10 columns with different contrasts between these lines. In other words, the line and the space between the lines have a different tone value for each column. Contrast is the difference in tone value. The lines and the contrasts vary stepwise over a logarithmic range, which can be defined in the header of the EPS file. The target works for devices with any bit depth or addressability.

Evaluation of Target

This target can be visually evaluated by reporting the lowest contrast at which a given line width still can be seen for the different colors and directions. A curve plotted from this data¹ gives an indication of modulation transfer. See Figures 1 and 2.

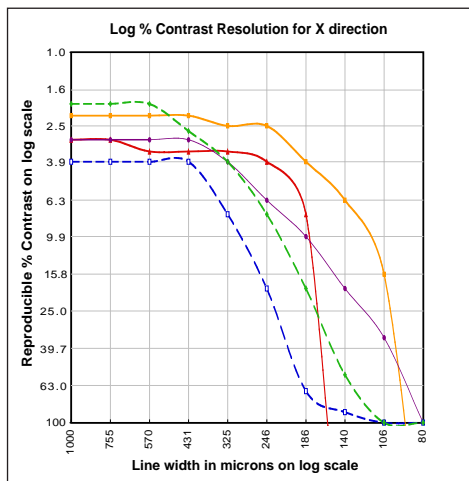


Figure 1. Evaluation of different printing systems

Orange line:	Epson Stylus Pro 5000, 6 color, ES RIP	720 spi	CRV = 619
Red line:	Xerox 5790, Splash Rip	400 spi	CRV = 366
Thin purple line:	Kodak Approval 28µ FM, Harlequin	1800 spi	CRV = 537
Green dashed line:	Kodak Approval 150 lpi AM	1800 spi	CRV = 416
Blue dashed line:	Kodak Approval 100 lpi AM	1800 spi	CRV = 322

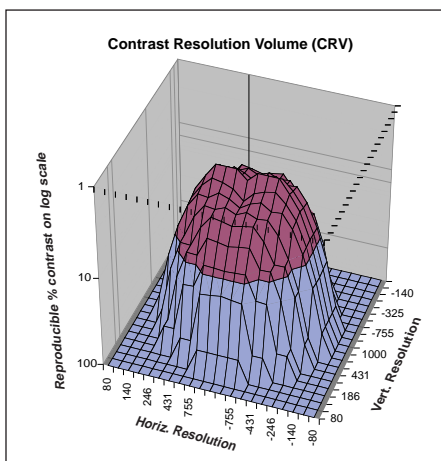


Figure 2. 3D representation of Approval 150 lpi AM

An Excel spreadsheet is available for analysis. It plots characteristic graphs and calculates the contrast resolution volume CRV. This vol-

ume is obtained by adding up, for each of the 10 contrast levels, the areas calculated by multiplying resolution in the X direction times resolution in the Y direction (fig. 2). CRV is a descriptive number for a given system.

The decision of what is and what is not resolved is somewhat subjective. It was found that it helps to train observers to get agreement between them. It was also found, that although different observers may use slightly different criteria for their decisions, they are very consistent within themselves. Therefore, they all agree on which system has higher or lower CRV¹.

Discussion

There is a clear difference of contrast-resolution between various printing systems. High addressability is not necessarily better. Using different types of screening on the same output device results in different CRV's as shown for the three Approval screenings. The good low contrast performance of the 150 lpi Approval print shown here (green line for X direction) was only average in the Y direction. The lower addressability of the xerographic printer limited high resolution at high contrast, but did not affect low contrast performance. The 6 colors of Epson do give good performance of low contrast resolution. Its addressability of 720 dpi was enough to also give good results at high contrast and fine detail.

Epson reports 1440 dpi for the Y direction (not shown here) and 720 dpi for the X direction. The CRV analysis did not show a significant difference between the two. It would be interesting to study the relation between the CRV results from the ConRes target and subjective evaluation of perceived quality of pictorial images.

Reference

¹ Eliot Harper, Franz Sigg and Dr. Edward Granger, An Investigation Into the Relationship Between Contrast and Resolution of a Printing System Using the RIT Contrast Resolution Test Target, TAGA 2001, pp 671-684.