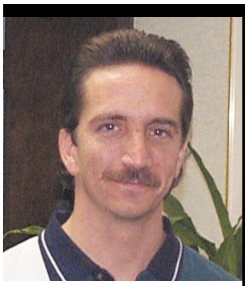
Color Accuracy: Resolution Is Not Enough!



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Good resolution is not enough for color accuracy and in fact it may work against you.

Perplexed? I don't blame you.

I have been dealing with the science of color reproduction for many years and I have discovered another blind spot in our color analysis methods and tools. Perfect stencil resolution does not necessarily mean perfect color reproduction.

The most obvious reason is because of our inability to reproduce the same resolution in the printed ink deposit. Dot gain and loss for various reasons contributes to this fact. This we have identified as an industry some time ago, but it is not the complete picture. I just completed an initial lab study on resolution-vs-acutance, and I want to share my findings.

First, let's define both resolution and acutance. Resolution is measured by the distance between lines and/or dots in an image. Perfect resolution is producing minimal to no variance from the actual or original distance between a line or dot and another line and/or dot

Ever had a color shift one day but not the next on the same image? More than likely the error was 3-D acutance — not resolution.

required by the image, by design or nature, giving us the ability to distinguish not only an accurate number of lines or dots but their actual size and shape.

Bad resolution to the extreme would be having no distance between two lines or dots. No distance between two lines would result in the resolution of only one line instead of two (Figure 1).

Acutance is normally the acute details of shape or sharpness of the line or dot's edge. You can have the correct distance between two lines and the lines may be the correct dimensional width (good resolution), but with close inspection the edge of the line may be jagged, curvy or irregular in one or more ways (bad acutance) (Figure 2).

The line may be in fact an uninterrupted

Figure 1

Figure 2

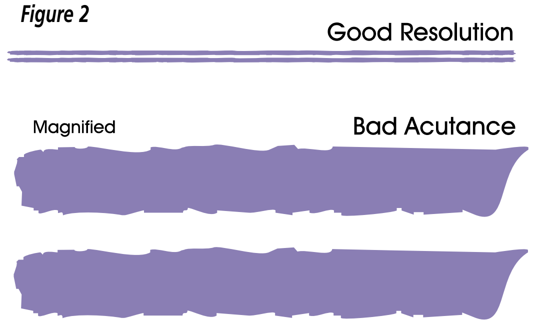
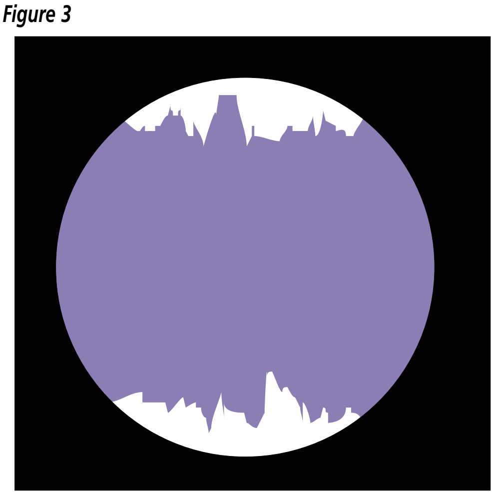


Figure 3



straight path from point to point (beginning to end), but the edge of the line can have many points made up of many lines going in different directions, whether straight or curvy, therefore having poor acutance (Figure 3, detailed Figure 2).

Resolution and acutance can be physically measured and evaluated, but often they are not. Normally it is a subjective evaluation, relying on opinion and the person's eyesight. That alone shows you why there has been little to no discussion or mention of image acutance.

Focused on acutance, however, I have a little insight on its value to share with you. Up to now, if acutance is considered at all, it starts and stops at the surface of the substrate. I am now going to challenge you to rise above the surface and give depth to acutance. "Three-Dimensional Acutance" will be the title and it will be defined as the acute accuracy of edge quality from the surface of the substrate where the ink begins, its lowest point, all the way to the top of the printed ink film, its highest point. In other words, Rz with an immediate change from a factor of 0 to its greatest factor or difference. You want a cliff with an immediate drop-off, not a hill will a gradual decline. No longer evaluate acutance at one level, if you are doing it at all, and look at it as the difference from the bottom of the ink to the top.

Concerned only with resolution and two-dimensional acutance, we will never get the color accuracy we dream of for the industry. Even the advent of another means of image analysis known as densitometry and spectrophotometry, we will still miss the mark if we do not start applying three-dimensional acutance to the color equation.

In addition to resolution, electronic printing is influenced by acutance as well, more so by three-dimensional acutance, having a direct effect on current and resistance. The ink missing from the edge of the printed ink film will be proportionately deducted from current while increasing resistance.

Hard-line definition is fuzzy, or softened, by poor acutance and compounded with poor three-dimensional acutance. With the difference between acutance, which is two-dimensional, and now three-dimensional acutance, I may be referring to 3-D acutance when just saying acutance in the rest of this article.

A considerable percentage of color error is attributed from image 3-D acutance. Dot loss is resolution loss. Color error is automatically considered a resolution, ink film thickness or ink color accuracy problem, or a combination of any or all. If dot 3-D acutance were not an actual part of the color sum, then this would be true in all cases. But as I have discovered, it is a large per-centage of the equation.

Color shift in highlight areas that are determined to be from dot loss or dot gain can actually be from 3-D acutance loss. The dot may, in fact, be resolved to its intended size (diameter) and shape (round, elliptical, square, etc.), but still measure an incorrect tonal percentage or hue error. This is because in a three-dimensional perspective the dot will have a geometric error or loss along the edge of the dot, or line if that is the case.

Technically the dot can measure acutantly (dimensionally) correct in a two-dimensional view from straight above, as it will cover the intended space or surface percentage of the substrate. But if we measure and map the shape of correct color density in an individual dot our true tonal percentage area is revealed (Figure 4). With the right view, lighting and thermal influence we can see a halo of incorrect color density around the perimeter of a line or dot. This halo starts with low intensity and increases as it goes in toward the center of the dot or line width.

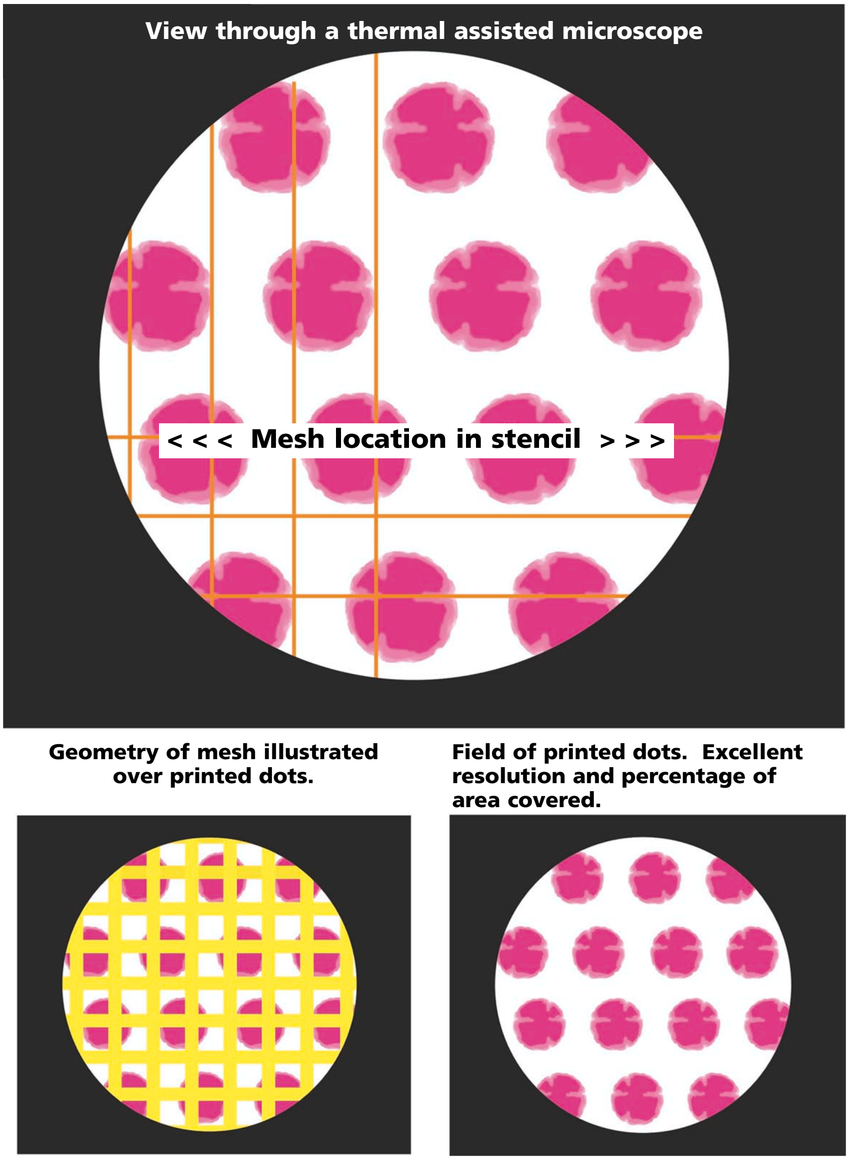


Figure 4

A densitometer or spectrophotometer does not measure dot 3-D acutance. It does measure the combined percentage of surface covered, including the combined surface and/or color density of all the dots within its viewing eye (Figure 5). It does not measure one dot individually. If a dot is resolved correctly therefore being dimensionally correct in diameter and distance from another dot it will measure with a density error, because its actual size in the mind of the meter is the sum of the area of the dot that is correct combined with the sums of the declining densities going outward to the edge of the dot, and then combined with the sums of all the other dots within the view of the meters eye. The dot covers the resolved area, but the entire area is not equal in density. If you were able to acquire good 3-D acutance the dot would have even density from the center all the way to its farthest edges. The same applies for lines.

When the meter shows a density loss, our natural reaction is to increase the size of the dots in that area, or overall. By increasing the size of the dot to acquire the correct tonal percentage or density, we are diminishing image resolution (the intended space between the dots). Remember, resolution is the two-dimensional space/distance between objects or dots in our case. If you lessen the dimension of the space between the dots you lessen resolution of the image in that area or tonal range, if specifically targeted. You can have color and/or density error in halftone areas with perfect resolution, because your 3-D acutance is poor.

Ideally, we should measure dot 3-D acutance and resolution when measuring color for accuracy.

Have you ever had color shift in a given tonal percentage one day but not on another in the same image?

Sure you have, and I bet you adjusted for it by either adjusting the curve in the computer and outputting a new set of films, with bigger dots or a higher percentage.

Or you increased squeegee pressure and/or angles, etc., to increase the dot size on the press.

The unfortunate thing with the latter is all percentages of dot sizes will be increased, not just the problem ones. The film approach is not the answer either because changing the resolution dimensions lessens the fidelity of the image, resulting in fine detail filling in or the image becom-ing coarse.

More than likely the color and/or density error came from a 3-dimensional error in the ink film (3-D acutance) not a two-dimensional error in resolution. You do indeed need to deal with conquering resolution before you can start to deal with 3-D acutance.

Importantly, you should know that when you change or alter the dot gain/loss curve of an image, you are physically changing the true and original resolution of the image, and it will not be globally equal within the image. Color shifts are increased as tonal percentages decrease.

After resolution, your focus should then be on dot 3-D acutance. You need to produce an ink deposit that is as three-dimensionally correct as possible.

If you want the dot to stand tall and with sharp edges you cannot butcher the viscosity and/or rheology of the ink. Ink rheology must be designed to transfer with as little fall as possible. Some ink will reproduce better 3-D acutance than others right now. Some ink will always have 3-D acutance error. They cannot hold a printed edge to the ink because of its fall from liquid flow after peel. Peel is the removal of the stencil from the surface of the print leaving only the ink to stand and hold its shape on its own. Plastisol and UV inks will produce much high 3-D acutance than solvent or water-based ink, potentially that is. You can build bad ink out of the best of materials with all the best intentions if your focus is not on the right demands.

High-density plastisol inks show the most potential for high 3-D acutance currently. When magnified you can see the even and sharp edge dimensions of a high-density ink deposit, if done correctly of coarse.

UV inks show the closest resulting 3-D acutance to high-density plastisol right now, and show the potential of producing even better. Besides other benefits of UV ink, and the hidden benefit of 3-D acutance, you will stand a better chance of dialing in your process and halftone films and prints with

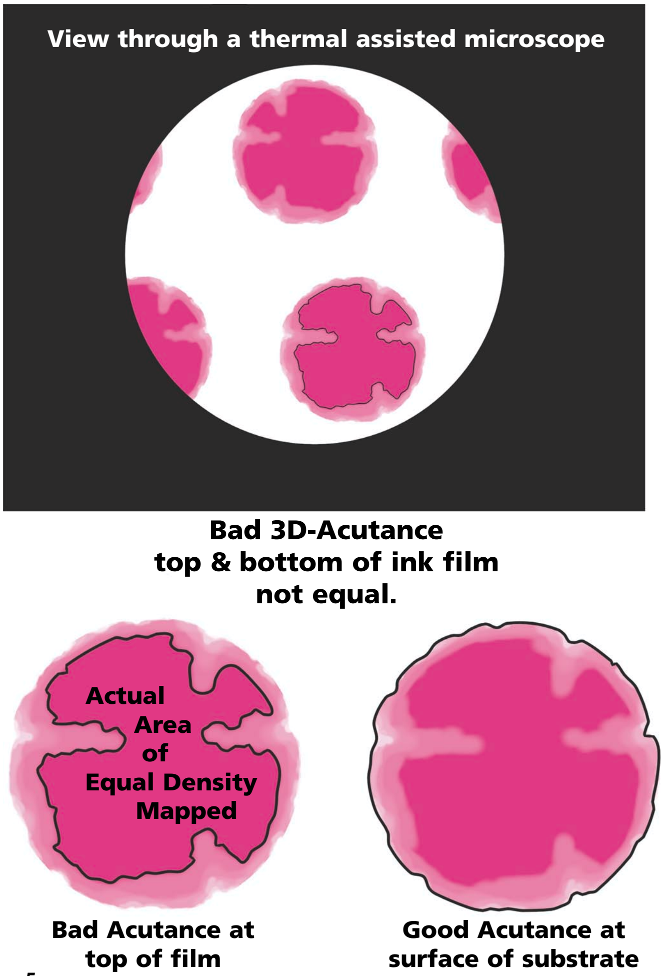


Figure 5

UV over solvent-based inks. Moving to UV is moving in the right direction for more reasons than being easy to work with and its environmental benefits.

Stencil Rz (surface roughness) has its effect on dot 3-D acutance as well. Bad or high Rz factors will result in poor acutance and force the sacrifice of resolution, which we will talk about in another article.

If color is more important than resolution to you, the image will be visually blurred but color correct. If resolution is most important to you, then the color will error but the image will be sharp and defined. To achieve both you have to go from the two-dimensional point-of-view and come into the 3D world and strive for high 3-D acutance.

Combine stencil quality and ink rheology with proper ink transfer techniques and you will improve your image 3-D acutance. Increase your available magnification and look at the ink from an angle and evaluate its three-dimensional shape and edge quality beyond where it contacts the surface of the substrate. Just the serious consideration or awareness of 3-dimensional Acutance will make a big difference in your printing. ■

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