Linotype-Hell

Technical Information

Digital Halftone Dots

Many people wonder why screen ruling and resolution need to be different. If the resolution is 2540 dots per inch, why don’t you set the screen ruling to 2540 lines per inch? Won’t that achieve better quality? The answer is no, for two reasons. First of all, screen ruling should be selected on the basis of the paper and printing press that you have chosen for the job. A 2540 line per inch screen ruling is much too high for any printing press to reproduce. (Screen ruling values commonly fall between 60 and 200 lines per inch.)

Moreover, if you were to set the screen ruling to be equal to the resolution, the resulting halftone would be able to reproduce only two levels of gray (either black or white). To explain this we’ll need to look at the way that PostScript** halftone dots are created. (For more information on halftoning, see *Resolution and Screen Ruling*, technical information document #3050.)

One Halftone Dot, Many Marks

Each halftone dot is made up of many individual marks. These marks, made by the exposure of a laser spot, are sometimes referred to as dots, spots, or machine pixels; but for the purpose of this document, the term laser spot will be used exclusively. You may have an easier time visualizing this if you think of an imagesetter as a tile floor maker that has the ability to put down either black or white tiles in a regular grid pattern. A halftone dot (or letter or graphic for that matter) is built tile by tile. (See Figure 1.)

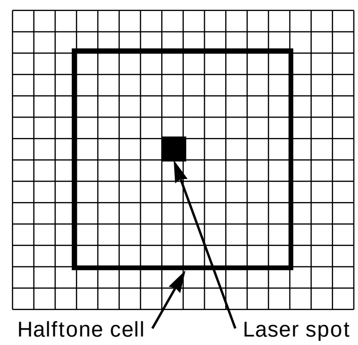

Figure 1 - The tile floor analogy

The grid in Figure 1 represents the imaging area, in other words, all the places where an imagesetter can make a mark. The small, solid black square represents a laser spot, the smallest mark that an imagesetter can make. The number of these laser spots that an imagesetter can make in an inch is often termed resolution but is more accurately called addressability. The large outline square encloses many of these potential laser spots and represents the boundary of a halftone dot. (This boundary is often referred to as the halftone matrix or cell.) If you were to count all the potential laser spots within the outline square and add one, that would be equal to the number of grays that this particular halftone cell is capable of producing. (The formula that can be used to predict this phenomenon is explained in greater detail in *Resolution and Screen Ruling*.)

In Figure 1, the halftone cell is ten laser spots long on its side. There are 100 locations in the box that can either be black or white. If the resolution is 1270 dots per inch, then this represents a 127 line per inch halftone because 127 of these halftone cells would fit in an inch. As long as resolution remains constant, increasing the size of the halftone cell decreases screen ruling (because less cells would fit in an inch) but it would increase the number of laser spots contained by the cell, and correspondingly increase the number of grays available. (See Figure 2.) Decreasing the size of the cell would increase screen ruling, but also decrease the number of grays.

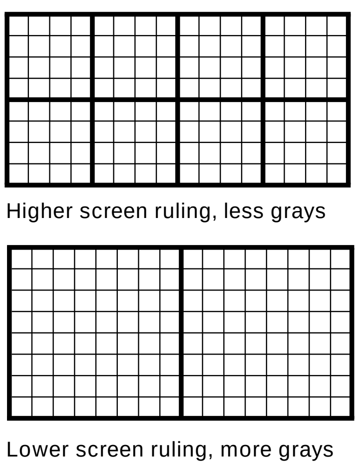

Figure 2 - As the halftone cell increases in size, so does the number of grays that it can reproduce; but at the same time, the screen ruling decreases. (This illustration represents a zero degree screen angle. The halftone cell is rotated to form other screen angles.)

Halftone Dot Shape

The actual shape of a halftone dot depends on how the laser spots that comprise it are arranged. You might think of it as assigning a number to each laser spot that determines the order in which they are made black. (See Figure 3.) For example, for a 25% halftone dot, one quarter of the laser spots would be black (in this case, numbers one through four).

The shape of the halftone dot plays an important role in the quality of a halftone or tint. PostScript has some incredible flexibility built into it for the control of the shape of the halftone dot. These controls can be used to achieve an artistic effect or to design a halftone dot that is particularly appropriate for the offset printing process.

Important: Don’t confuse the shape of the halftone dot with the shape of the individual marks that are used to build it. Figure 1 is a simplification; the tiles shown are square, but the actual laser spots are closer to oval in shape. Nonetheless, the analogy is an accurate one. However, please be sure that when you consider halftone dot shape, you are not confusing it with the shape of the laser spot.

15	6	11	16
10	1	2	7
5	4	3	12
14	9	8	13

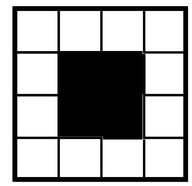

Figure 3 - A halftone cell with ordering priority marked with numbers (top).
A 25% halftone dot created using that order (bottom).

Early PostScript Halftone Dots

As a way of illustrating the importance of halftone dot shape, let’s look at some examples of halftone dots and how they affect the printing process. In the early days of PostScript it was thought that a halftone dot should be perfectly round. The people who programmed it did just that. They made a round halftone dot that got bigger and bigger until it reached a solid black. (See Figure 4.)

Figure 4 - A blend using the round halftone dot shape shown at a very low screen ruling so that the individual halftone dots are visible.

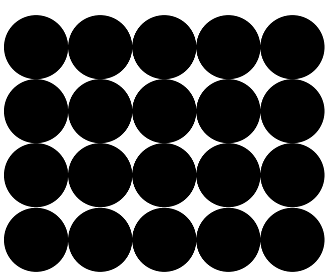

Figure 5 - Magnified illustration of the star-shaped white spaces that appear in shadow areas of tints created with an ever-increasing round halftone dot.

You can see that in the darker areas of the blend (once the edges of the circles meet) you actually get open spaces that look like little four-pointed stars. People soon realized that these little stars tended to fill in with ink when the halftones were run on a printing press. (See Figure 5.) This meant that shadows came out looking darker than they should.

When the engineers at Adobe** Systems went back and took a closer look at the halftone dots that printers had been creating photographically for years, they saw a much subtler halftone dot shape. Instead of a circle that just kept getting larger, what they saw was a circle that became a square around 50% and then became an open white circle on a black background. This kind of halftone dot shape is not as likely to fill in with ink in the darker areas. As a result, the engineers created a halftone dot that starts out and ends up round but is square at 50%. It became the new PostScript default halftone dot shape. (See Figure 6.)

Figure 6 - The improved PostScript default halftone dot shape.

Optical Jump

The new PostScript default halftone dot shape was a major improvement, but it shared an age-old problem with conventional halftones. As the halftone dot approaches 50% there comes a point where all four corners connect with the corners of adjacent halftone dots. (See Figure 7.) What this does is to give the visual impression of a sudden increase in the darkness of a tint. Printers refer to this as optical jump. Elliptically-shaped halftone dots can reduce optical jump because as the ellipse increases in size, the ends on the long side meet before the ends on the short side. This divides the optical jump into two stages, and the result is a smoother rendition of the gray scale.

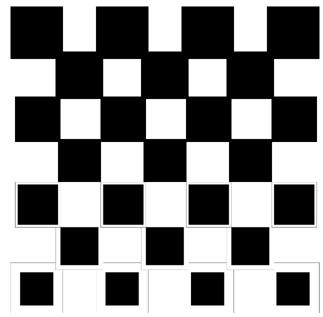

Figure 7 - Optical jump may occur in a halftone dot shape that is square near 50%.

Figure 8 - An elliptical halftone dot shape.

A Common Terminology

When describing a halftone dot shape it is best to start with what happens at a 50% tint. Most halftone dots should be circular at both low and high percentages. But what happens to them around 50% is most important. A square halftone dot therefore would be round at the lower percentages, square at 50% and round again at the higher percentages.[1] An elliptical halftone dot would follow the same pattern, but instead of being square at 50% it would be elliptical. Some halftone dot shapes (and these are ones that are used primarily for a funky visual effect) maintain a similar shape throughout. A line halftone pattern is an example of this. (See Figure 9.)

[1] Although it would be possible to create a halftone dot that would be square throughout, there is little reason to do this except for visual effect.

Figure 9 - A line halftone dot shape.

The Spot Function

The PostScript spot function is a mathematical description of what the halftone dot should look like. Essentially what it does is to take a mathematical formula (for a circle for example), and use it to determine the order in which the marks comprising a halftone dot are arranged.

Unless you are familiar both with geometry and PostScript programming, the spot function itself may be difficult for you to use. But for those of you who are interested in more information, here are some books that discuss how the spot function works:

PostScript Language Program Design (The Green Book), Adobe Systems Inc., Addison-Wesley Publishing Co., 1988, p. 131-136.

PostScript Language Reference Manual (The Red Book), Adobe Systems Inc., Addison-Wesley Publishing Co., 1985, p. 80-82, 221.

Real World PostScript, Stephen F. Roth Ed., Addison-Wesley Publishing Co., 1988, p. 170-175, 209-210.

Designer Halftone Dots

An interesting aspect of all of this is how the spot function can be used for artistic effect. At coarse screen rulings[2], the shape of the individual halftone dots is visible, and can be very appealing. Figure 10 shows two examples of the output of spot functions that result in intricate halftone dots.

[2]High resolution PostScript imagesetters usually have a minimum screen ruling of around 20 lines per inch.

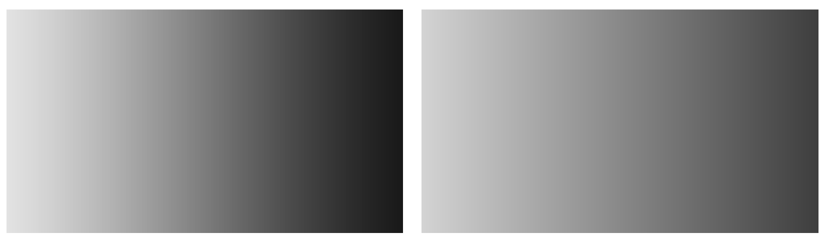

*Figure 10 - Bow tie halftone dot shape (left) from FountainView**, and windmill-shaped halftone dot (right) developed by Linotype-Hell Company.*

One program that has taken advantage of this is called FountainView. It contains encapsulated PostScript files (EPSF) of blends created with a variety of halftone dot shapes that may be used as backgrounds or for dramatic effects. For information on FountainView, call Isis Imaging at 1-604-873-8878.

Conclusion

The shape of a halftone dot is a subtle but important factor in quality halftone output. Of perhaps greater importance in understanding digital halftones, however, is one single piece of information: each halftone dot is made up of one or more laser spots. Understanding this makes the relationship between screen ruling, resolution, and grays much easier to comprehend.

Comments

Please direct any questions or comments to:

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