Technical Information

Halftone Dot Shape

The shape of a halftone dot plays an important role in the quality of a printed image. Halftone dots are really quite complex, and if you examine them closely, you will find some very subtle variations between different halftone dot shapes. However looking at a single halftone dot at a specific dot percentage doesn't tell you the whole story. It is much easier to see these differences if you visualize a halftone dot shape in three dimensions. This kind of representation of a halftone dot is sometimes called a halftone mountain or rasterberg, but will be referred to here as a three-dimensional dot matrix.

For background information on topics related to halftoning, please refer to the following Linotype-Hell technical information pieces: Digital Halftone Dots, Hard Dot/Soft Dot, Moiré, What Factors Play a Role in Moiré, Rational and Irrational, and Measuring Screen Angle and Ruling.

Dot shape in three dimensions

Imagine a single row of halftone dots ranging in size from 0% to 100% in increments of .4%. These 256 halftone dots represent the gray steps from no halftone dot at all (white) to a solid black. If each of these halftone dots had a given thickness, and you stacked them on top of each other with the largest one at the bottom and the smallest one at the top, the result would be a three-dimensional representation of the halftone dot shape. (See Figure 1)

The volume formed by this three-dimensional dot matrix defines the halftone dot shape. Horizontal slices from this volume reveal what a halftone dot will look like at a specific halftone dot percentage.

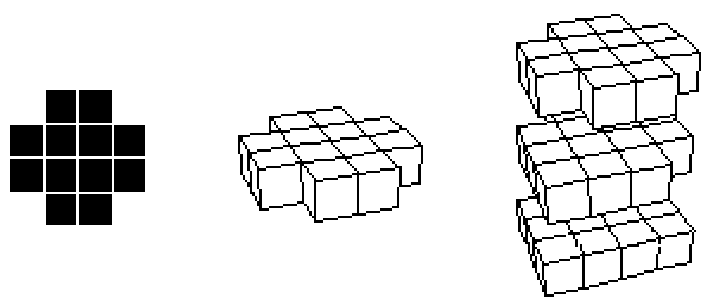

Figure 1 - A two-dimensional representation of a halftone dot (left), a three-dimensional representation of a halftone dot (center), and several three dimensional halftone dots stacked on top of each other (right).

The mathematics

The volumes in a three-dimensional dot matrix are mathematically defined. While some are extremely simple mathematically, others require sophisticated formulas. Take for example a simple formula for a circle: $X^2 + Y^2 = 2$. This defines a circle with a radius of the square root of 2. However as a spot function[1], it describes a halftone dot that begins as a small round dot and continues to grows in a round fashion. Another simple function, $X + Y = 2$, describes a line. As a spot function, this formula would create a series of parallel lines. An even more complex formula creates the round/square (or Euclidian) halftone dot. This dot shape is round at low and high percentages, but forms a checkerboard at 50%. (See Figure 2 on the following page.)

[1]Spot function is the PostScript** term for the formula used to create a halftone dot shape. The spot function determines the placement of individual laser spots within a halftone cell.

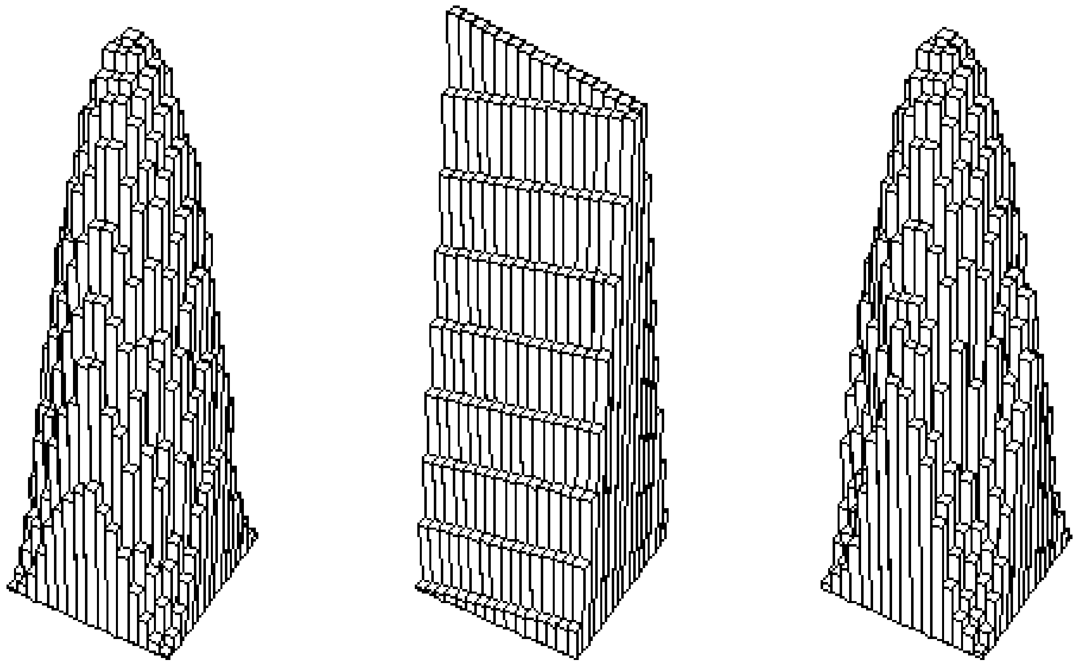

Figure 2 - Three halftone dot shapes shown in three dimensions: round (left), line (center), and round/square (right). The round and round/square dot shapes are very similar, in fact the tops are identical. It isn't until the midtone that the round/square deviates from the round. Notice how a small triangle is formed on the edge of the three-dimensional dot matrix. This triangle indicates the areas where neighboring halftone dots join. The top of the triangle is much lower in the round dot shape. This means that the halftone dots begin to meet at a higher dot percentage in the round dot than in the round/square. This effect becomes particularly visible in Figure 4 on the last page.

Naming conventions

The terminology used to describe halftone dot shape can be misleading. With simple dot shapes, a single word may be sufficient to describe the dot shape. For example, the term 'round' adequately describes a halftone dot that starts out and continues to grow round. However, some dot shapes may require a sentence or more to describe them. The round/square dot is a good example of this. It has been called round/quadratic, Euclidian, or even just round or square. If you call this dot shape *round* that doesn't explain the checkerboard at 50%. Similarly, *square* does not describe what is happening in the highlight and shadow. *Euclidian*, although interesting for its connection to a geometric formula developed by Euclid, doesn't tell you anything about the shape. (See Figure 3.) *Round/square* or *round/quadratic* (where quadratic is a fancy word for square) are better descriptions, but still not very exact.[2]

Elliptical dot shapes can be even more intricate. Many different elliptical dot shapes exist. An elliptical halftone dot shape might be elliptical from the highlights to the shadows. It might be elliptical only in the midtone, and round elsewhere. The ellipse might be shaped like a football, or perhaps a diamond or a hot dog. It is only when you look at the relationship of a halftone dot to its neighbors that the importance of these shapes becomes apparent.[3]

[2]Round/square is the default halftone dot shape in most Linotype-Hell raster image processors. The RIP 60 uses an elliptical halftone dot shape as its default.

[3]Many of the elliptical dot shapes used within the PostScript page description language are not well-designed. It is not a simple task to program a well-formed elliptical dot.

The neighbors

Looking at a single three-dimensional dot matrix doesn't immediately reveal how neighboring halftone dots relate to each other. Viewing several placed side-by-side gives a better indication of this. (See Figure 4 on back page.) This is a very important issue, probably the most important one concerning halftone dot shape. As neighboring halftone dots merge together, ink may gather at these junctions. The result is an increase in the darkness of a gray. This effect is usually called mid-tone or optical jump. It is most visible in blends or subtle areas of scanned images.

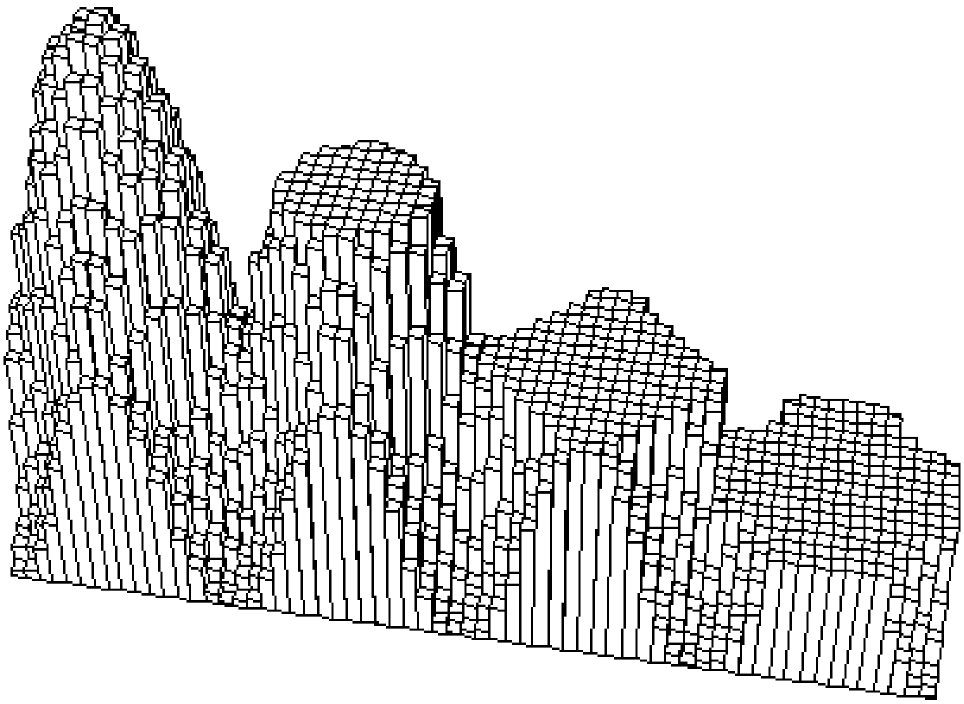

Figure 3 - Four neighboring three-dimensional dot matrices, shown in cross-section. One is shown in its entirety (left), while the three others are shown as cross-sections: quartertone (left center), mid-tone (right center), and three quartertone (right).

The prime example of mid-tone jump is what occurs with a halftone dot shape that becomes square at 50%. Neighboring squares form a checkerboard pattern. This is a key characteristic of many 50% tints. As you approach a 50% tint, the four corners of each square 50% dot merge with its neighbors. Since all four corners merge relatively quickly, and since ink may gather in these crevices, the result is a noticeable jump in density.

Halftone dot shape can be used to shift mid-tone jump. For example, with a round dot, the merging of neighboring dots takes place at a higher dot percentage. Shifting the mid-tone jump towards the shadows in this manner is often preferred for flexographic printing. Another strategy is to divide the mid-tone jump in two. This is what an elliptical dot shape does. This occurs because the ends of the ellipse merge first (somewhere between 30% and 50% depending on the way the shape is created) and only later do the sides meet (between 50 and 70%).

The Linotype Utility 6.0

In a PostScript environment, the Linotype-Hell Utility 6.0 gives you the ability to choose halftone dot shape. This provides you with the Hell ‘repro’ halftone dot shapes. The Hell ‘repro’ dot shapes are the result of years of research and testing on halftone dot shape. This is a particularly important factor in the elliptical halftone dot shape, since the joining of the short end and long end must be done properly to minimize mid-tone jump.

Conclusion

The role of halftone dot shape is important in mid-tone jump,but it plays a lesser role in calibration and moiré:

- Calibration is done to assure that the halftone dot size that you request is the halftone dot size that you get. The shape of the halftone dot will only have a significant affect on the calibration curve in those areas where adja-

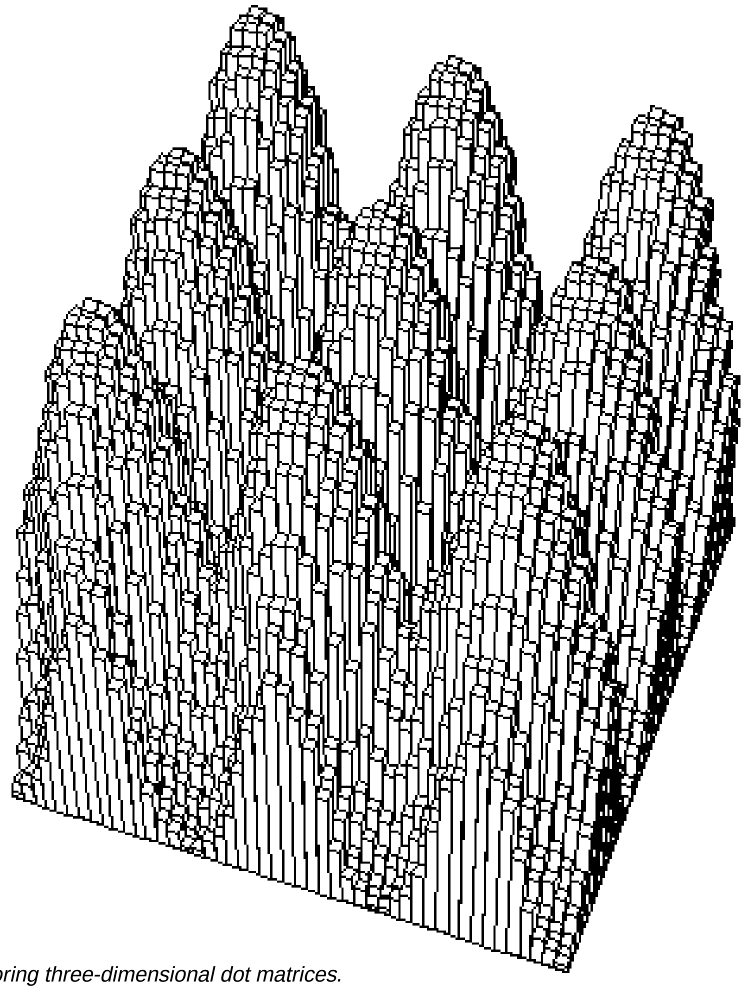

Figure 4 - Nine neighboring three-dimensional dot matrices.

cent halftone dots meet. Still, there is no sense in trying to correct this through calibration, you should simply select the most appropriate halftone dot shape for your job.

- Moiré in color work is usually a result of improper screen angle and ruling combinations. Changing the halftone dot shape will have little effect on moiré. This is because the creation of a halftone dot shape is independent of the screen angle and ruling for most halftoning methods.

  In some cases, patterns formed by halftone dots may become visible at lower screen rulings. For example, elliptical dots form chains when the ends of neighboring ellipses meet, but strictly speaking, this is not moiré.

Comments

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