Technical Information

The Scanning Process

Linotype-Hell

Many people are concerned that the quality of scans from desktop scanners does not match the quality of scans from so-called high-end or repro scanners. While there are many reasons for a potential quality difference, one important factor is the color computer. Desktop scanners rarely have a dedicated color computer. Most high-end repro scanners do.

Why is a color computer so important? Because it handles color space translation, unsharp masking, and a host of other critical details. With desktop scanners the color computing is usually done on a Macintosh** computer by an image manipulation/color separation software application. While this may be attractive for design purposes, it may be less than desirable for speed and quality reasons. To help understand the role that a color computer plays in quality and productivity, we'll need to look at the scanning process.

For background information on color, please refer to the Linotype-Hell technical information pieces entitled, Color in Printing, and, Color Spaces and PostScript Level 2.

Scanning

The process of scanning and outputting an image can be divided into five components:

- The analyzing unit
- The color computer
- The scaling computer
- The electronic dot generator (sometimes called the electronic screen computer)
- The exposure unit.

Functions performed by a color computer
- Unsharp Masking
- Color Correction
- Tonal Adjustments
- Setting highlight and shadow
- Gray balance
- RGB to CMYK conversion
- Under color removal
- Gray component replacement

The *analyzing unit* examines the original image and sends these values to the color computer. The *color computer* performs a range of functions (see box to right), after which the *scaling computer* adjusts the image to the desired output size. Then digital data is supplied to the electronic dot generator. The *electronic dot generator* converts the data supplied by the color computer to drive the exposure unit. This amounts to creating halftone dots at the desired size, screen angle, and screen ruling. Finally, the *exposure unit* exposes the film based on the signals generated by the electronic dot generator.

Note: There are some gray areas between the functional components of analyzing unit, color computer, scaling computer, electronic dot generator, and output device. For example, some early analog scanners handled unsharp masking with a separate photomultiplier. (This is in addition to the red, green, and blue photomultipliers.). For these scanners, unsharp masking would be considered an analyzing unit function rather than a color computer function.

Analog and digital

In the past, many scanners manipulated data in analog form. Today, most graphic arts scanners manipulate digital values. If the data is analog, it must be converted to digital form to be output on a recorder. The difference between an analog and a digital scanner is something of a semantic one.

When data is first captured by any scanner, it is in analog form. (In this sense, analog means a continuous wave or signal that is represented by variations in electrical voltage.) If this analog data is converted to digital form *before* it is manipulated by the color computer, then the scanner is considered digital. If it remains analog during color computing, then the scanner is considered analog. Therefore the defining point factor is when the scanner makes the conversion from analog to digital.

Similarly, all graphic arts scanners read data as RGB values (red, green, and blue). However, there are some high-end scanners that convert this data immediately into CMYK (cyan, magenta, yellow, and black). These scanners, though called CMYK scanners, still use RGB sensors.

Dividing up the process

Repro scanners like the Linotype-Hell DC380, CP345, DC350, CP340, CP341, and C399 all contain an analyzing unit, a color computer, scaling computer, an electronic dot generator, and an exposure unit, but it is not uncommon for these functions to be split up among more than one device. (See Figure 1.) For example, the devices in the Linotype-Hell 3000 series are split into an input and an output portion. The Linotype-Hell S3010 scanner contains the analyzing unit, the color computer, and scaling computer. It handles input. The Linotype-Hell R3020 and R3030[1] recorders contain the electronic dot generator and the exposure unit. They handle output.

[1]The 3030 has the larger output format of the two: 43.7 inches x 29.5 inches.

Among mid-range or desktop solutions you often see the components split among four separate devices: a scanner acting as the analyzing unit, a combination of hardware and software as the color and scaling computers, a raster image processor as the electronic dot generator, and a Linotronic* imagesetter as the exposure unit.

All of these functions are equally important. Whether the functions are handled by one box or four is not the issue, it is how each function is performed, because if just one link in the chain fails, the result is poor quality.

Calibration issues

There is nothing inherently wrong with separating the color computer from the analyzing unit, but it can make the process more difficult. For one thing, if the color computer is not part of the scanner, it becomes impossible to do any manipulations during the scan. (Although you can certainly accelerate these operations later.) Also, it opens up a gap, a potential lack of knowledge about the source of the scan. A color computer can perform at it's best when it is tuned to the RGB sensors of the analyzing unit.

Imagine the difficulty of a PostScript** service bureau that must output scans from many sources. Really, all they can do is output them, they can't make any guarantee of quality in the final result, because two important parts of the puzzle are beyond their control: the analyzing unit and the color computer. There is simply no way to fully calibrate a system unless you can follow what happens from beginning to end. When the analyzing unit and the color computer are separate, you open up room for error. This is one reason why WYSIWIG (What You See Is What You Get) has been so difficult to achieve in practice.

This is the bind that faces anyone involved in production these days. A closed system makes it much easier to calibrate and assure quality. However at the same time a closed system may not be flexible enough to meet the demands of today's designers and production professionals.

Design

The components outlined in the previous section do not include any design functions. Design functions like retouching/pixel cloning, cropping and sizing after scanning, color correction using restriction masks, drop shadows, or

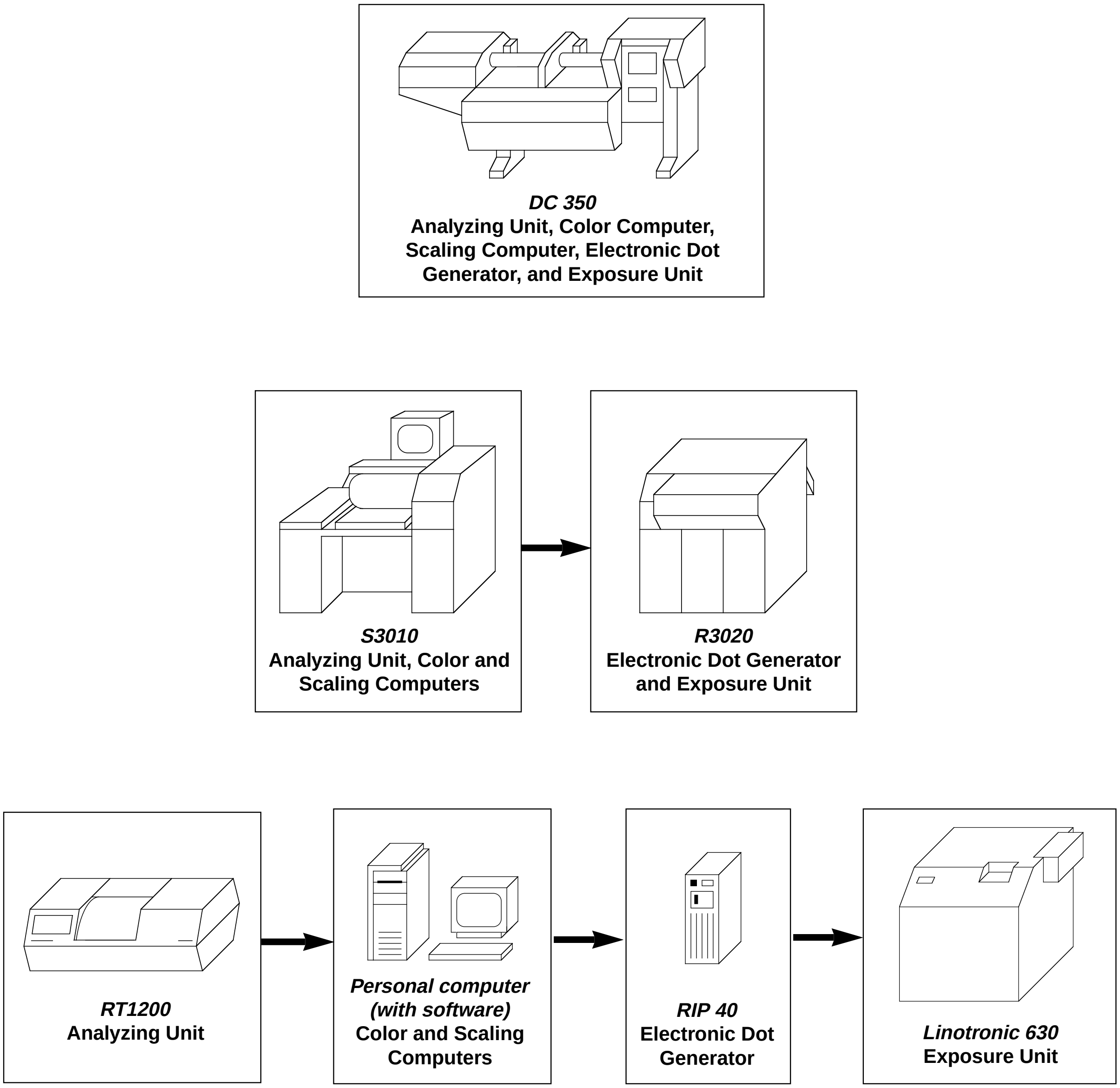

Figure 1 - Several possible arrangements of the four components of the scanning process: analyzing unit, color computer, electronic dot generator, and exposure unit.

montage are usually done on a separate design workstation. While these functions may be performed by some color computers, they generally are done separately. This allows the scanning process to be accelerated as much as possible.

Accelerating the process

The color computer of a high-end scanner can handle many functions on the fly that must be dealt with in subsequent operations on the desktop. Therefore desktop scanners often fail in speed comparisons with a high-end scanners. When sophisticated hardware and software allow you, for example, to color separate in real time, it is no surprise that an effective color computer results in a quality and production edge.

Look-up tables

Scanner look-up tables are one area where hardware acceleration is particularly important. With eight-bit color, a look-up table would contain nearly 17 million entries. When an exact value is not found in the look-up table, an estimate is made based on the surrounding values. This process, interpolation, can be handled more accurately if the look-up table is large. This helps in the rendering of subtle colors. The real trick is to balance the size of the look-up table with the ability to interpolate values that aren't represented in the table. One hallmark of high-end color computers is that they can make hefty look-up tables and accurate interpolation run quickly.

Look-up tables can be considered two-dimensional, or three-dimensional. A two-dimensional look-up table can be used to carry out copy range instructions (i.e., setting white, black as well as tonal adjustments.) A three-dimensional table (sometimes called a color cube, see Figure 2) can represent a color space.

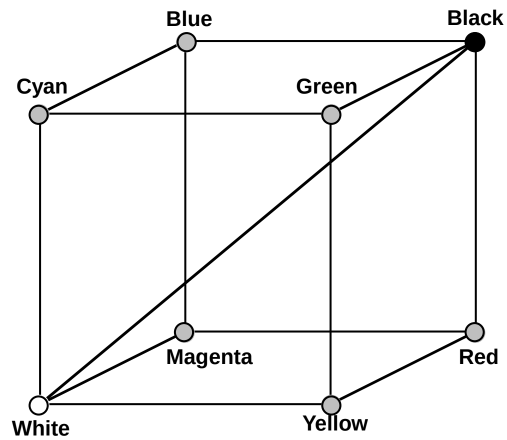

Figure 2 - A color cube

PostScript Level 2

PostScript Level 2 has opened up the possibility of calibrated color through the use of color rendering dictionaries. These dictionaries would actually move some of the functions of the color computer into the page description language where they would be handled by the RIP (Raster Image Processor). While this approach shows some promise, it will require effort both on the part of manufacturers and users. For the moment, users will look to handle the color computing elsewhere.

Comments

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