Linotype-Hell

Technical Information — Color Management

Color management is the process of making scanners, monitors, and output devices work together to produce the best result for the target printing process. The ability to manage these various devices makes or breaks a color management system. In the past, pre-press systems were closed, i.e., the hardware and software components were carefully selected by the vendor. It was not possible for a system buyer to choose from a laundry list of different manufacturers software, scanners, monitors, or output devices. Because the system was closed, it was easier for the vendor to know what to expect from each step. But times have changed. We live in a world of off-the-shelf software and open systems. The challenge for vendors and users is to provide the same consistency as closed systems, but using a wide variety of hardware and software.

Color management tasks

There are three critical color management tasks:

- Input device calibration (i.e., device dependent input from scanners, etc.)
- Device dependent output adaptations (i.e., transformations for each different printing or output process)
- Monitor calibration

We will look at each of these steps individually, and then look at how each step interacts.

Input device calibration

In an open environment, users may choose between many types of input devices to grab visual data including scanners of all types and sizes, video cameras, and digital cameras. Each device’s input may differ for a variety of reasons including:

- The device’s light source - Since color is perceived by the eye in terms of wavelengths of light reflected off of an object, the nature of the light source plays a large role in color perception. Likewise, the light source is a critical link in determining how color is perceived by a scanner’s sensors.
- Sensing technologies - Sensing technologies, such as photomultipliers and charge-coupled device arrays (CCDs) perceive color differently.
- RGB filters - The red, green, and blue translucent materials used to filter the light from an image have their own color transmission characteristics which play an important role in how the light is perceived by the sensors.

These factors make it difficult to generalize about RGB scanners. Color matching becomes extremely difficult in an open system unless a color management system is in place that includes both calibration techniques and a device independent color space like CIE.[1]

[1]CIE (Commission International de l’Eclairage) has developed a range of color standards. For more information on CIE color spaces, please refer to the Linotype-Hell technical information articles entitled Color Spaces and PostScript Level 2, and Color Space Transformation.

Device dependent output

Printing processes vary even more than scanners. Different inks, toners, and dyes mean that the color space of the target medium may vary greatly from one process to the next. Currently, the process of producing digital data on film seldom incorporates an accurate consideration of the color gamut of the target medium. Many companies in North America produce their films to yield good color based on the SWOP standard (Specifications for Web Offset Printing). These companies also use their experience to compensate for differences in dot gain, gray balance and tone compression when they know that the job will be printed on a particular paper stocks.

Differences in substrate, ink sets and printing process require that attention be paid not only to dot gain and gray balance, but also to color correction. It should be obvious that a combination of CMYK (Cyan, Magenta, Yellow and Black) values that produce a given color response for one paper and ink set, may not produce the same color if a different paper or ink set is used. The CMYK values that produce an acceptable red under SWOP conditions are unlikely to produce the same color if printed on plastic substrates in flexography or corrugated substrates for packaging gravure. Unfortunately, technology supporting precise finger printing of the actual press conditions has largely been unavailable until now.

Monitor calibration

While monitors are good for judging page content and indispensible in image retouching, in many cases it is best to rely on cursor readings for precise color matching requirements. Why? Because colors on-screen do not nearly approximate what the printed inks will look like on paper. If, on top of that, you are working with a software application that displays RGB data without factoring in the effects of the CMYK print space, there is little hope of matching screen to print. Even when the software application displays the image based on CMYK data, the conversion must be sophisticated to be accurate. Many programs use a crude inversion of CMY values to drive the RGB of the monitor. The K data is dropped all together which results in a poor simulation.

To be truly calibrated the RGB properties of a given monitor must be known and counted on when formulating display algorithms. Even when the monitor properties are defined and factored into the display algorithms, monitor variation must be taken into account. The phosphors in color monitors are subject to aging or decay, and they may also be affected by magnetic interference. As monitors age they must be recalibrated, but often this is not possible since many monitors lack the tools which allow them to be calibrated.

Can anyone offer WYSIWYG (What You See Is What You Get) when the characteristics of the output print media aren't taken into consideration by the algorithms used to display the data on screen? Of course not. Without proper color management this is impossible. The response proprieties of the RGB phosphors must be known, and there must be calibration tools to keep the monitor within a specified range. In addition, it is the responsibility of the end user who employs color management, to support proper ambient lighting and viewing conditions so that the aforementioned calibrations will be valid.

CMYK print simulation

The ability of a monitor to simulate the printed piece also depends on the color gamut that the monitor can display. Some colors, particularly reds, may be displayed on a monitor but are too saturated to be printed by conventional CMYK inks. Because portions of the RGB color gamut may extend beyond what is printable with CMYK inks, the RGB display may show detail that will be lost when the image is printed. These are compelling reasons for CMYK print simulation.

Color management principles

Color management within LinoColor* 3.0 follows the following procedure:

- Calibrating an RGB scanning device - By scanning and measuring the Kodak Q60 test target (which contains a wide range of color values) the input RGB values for each color can be converted to approximate CIELAB[2] values through a look-up table. Next, these measurements are compared against the actual CIELAB values as measured directly on the Q60. The look-up table is then refined to accurately map the RGB values of that particular scanner to CIELAB values. These look-up tables allow high-speed,

[2]CIELAB is one of the color spaces developed by the Commission International de l'Eclairage.

compute intensive, three-dimensional color transforms to be carried out during the input scanning process.

The scanning process is also affected by the film type of the original. Different types of film materials may be perceived slightly differently by different scanners. To account for this, Linocolor 3.0 provides print tables for the most common types of film.

- Print Process Calibration - After the image is scanned and edited using LinoColor 3.0, a series of transformations and interpolations[3] are performed to move the data from CIELAB to the target device dependent space. This final color transformation is accomplished through a process called Print Process Calibration (PPC).

  A specially-designed print target is used to fingerprint the actual color gamut of a particular ink set, paper stock or substrate, and printing process, such as sheetfed offset, heatset or non-heatset web, flexography, and publication or packaging gravure. Once the target has been output and printed, it is measured in order to derive CIELAB values. These CIELAB values are then stored in a look-up table together with the known CMYK readings for each sample on the target.

  With this test as a foundation, image data may be transformed from CIELAB into the CMYK of the target process. UCR (Under Color Removal), GCR (Gray Component Replacement), highlight and shadow placement, and other print specific factors may be introduced through the use of simple look-up tables.

- Monitor calibration - The monitor calibration must also take these CIELAB values into account. Using a special routine, the CIELAB values from the PPC press target, can be combined with the known color phosphor response characteristics of the monitor. (LinoColor offers two factory calibrated RGB monitors for this purpose.) After these values have been generated, they are placed in a look-up table and used for transformation during the screen display process. Images on screen are displayed in RGB, but with LinoColor you may choose to display an image using either:

  The internal CIELAB values converted to the monitor RBG, but not taking print conditions into account, or

  The internal CIELAB values transformed using specially-created look-up tables to yield a CMYK simulation on screen.

[3]Moving from one color space to another requires a transformation. To accurately perform this color transformation, a technique called interpolation is often used. Color transformations are based on tables of values (like those generated by PPC). Interpolation allows estimations to be made based on the data in a table, and allows these color tables to be a reasonable size. Without interpolation, the color tables would have to be immense to be accurate.

MacCTU

One characteristic of these CIELAB transformations between scanner, monitor, and output device is that they are extremely compute intensive. To support this process in a production environment requires special hardware. For this purpose, Linotype-Hell has developed the MacCTU. (Macintosh** Color Transformation Unit.) The MacCTU is actually a color computer that fits on a single integrated circuit board in a NuBus slot of Macintosh.[4]

The MacCTU is the heart of Linotype-Hell's color management system. The heart of the MacCTU is a large custom ASIC (Application Specific Integrated Circuit). This ASIC accelerates high speed, compute intensive transformations and interpolations. To give you an idea of how fast this board is, a three-dimensional transform may be performed on a 20 megabyte image file in approximately 30 seconds. With this kind of speed, accurate color transformations from any CIE color space become viable in a production setting.

[4]Ten years ago, the color computer in a new Hell scanner was made up of approximately 20 integrated circuit boards.

User interface

Part of the user interface that Linotype-Hell has selected for LinoColor 3.0 is a color space called LCH. This CIE color space is described in greater detail in the Linotype-Hell technical information piece entitled Color Space Transformation. Briefly, LCH is based on the intuitive color model of the Munsell Color Matching System. LCH stands for lightness, chroma, and hue. LCH provides the user with the ability to correct the lightness, chroma and hue attributes of a color image independently.

LCH corrections can be performed on both a low resolution view file or on a high resolution image file. The MacCTU makes the changes either during the subsequent high resolution scan or by flowing the high resolution file from the random access memory or hard disk through the MacCTU board.

LCH adjustments

Color adjustments using LCH may be done in three ways:

- Lightness - Lightness adjustments brighten or darken an image without influencing hue or chroma. In a CMYK-based system, this process can be intricate and time intensive. CMYK-based operations will require adjustments to all four color channels and at multiple points on the gradation curve. With LCH, lightness adjustments are a simple one-step operation.
- Chroma **-** Chroma influences the purity of a color. By adjusting chroma it is possible to make a color more or less vivid without changing its hue.
- Hue - Using hue correction, it is not only possible to make radical color adjustments rapidly, but they can be done in such a way as to hold subtle detail. On many CMYK-based systems, radical color changes will cause a noticeable loss in subtle detail.

LCH is simply another way of displaying CIELAB. CIELAB makes it possible to take object readings from fabric or color swatches using a hand held spectrophotometer and directly enter those values for precise color matches.

Automatic image analysis

Experienced scanner operators know that proper placement of the white point, shadow point, gradation and color casts accomplishes a large percentage of the work necessary in producing a good quality scan. Automatic image analysis can automate this process. Using ColorAssistant (which is part of LinoColor), a low resolution view file from any of the scanners supported by LinoColor is analyzed. Then, statistical and mathematical algorithms are used to examine the gamut of the image and predict optimum settings for highlight, shadow, contrast gradation and color cast. ColorAssistant provides assistance for many novice operators and relieves experienced operators from routine, time intensive tasks in order to concentrate on more creative and critical color matching issues.

Conclusion

There are many different components of a color management system. To start, calibration must be handled on a range of devices. Then, the process, which can involve some incredible amounts of calculation, must be accelerated to fit the needs of a production environment. Finally, anything that can be done to make the job easier for operators increases the effectiveness of the color management system as a whole.

Comments

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