Process Color Profiling: Syncing a Digital Press with an Offset Press

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Abstract

For both printers and clients, accurate proofs are needed before going to press. The proof should predict what the job would look like on the press. Press proofing is an integral part of the printing process. It is important to customers that the colors on a digitally printed proof will match the colors printed on an offset press. The Larry Brink Printing Laboratory at Western Michigan University uses a Xerox Docucolor 12 for printing proofs for a Shinohara offset press. This project examines digital color proofing the offset press. In order to accomplish this, an ICC profile target was printed on multiple substrates on the offset press and the digital printer. These were measured to create output profile for the two devices on the different substrates. These profiles were used to simulate the offset press with the digital printer. The proof was verified both numerically and visually. The experimental procedure, results and reasons for differences are discussed.

Introduction

Color reproduction needs to be consistent. An image should look the same on the computer Monitor as it does when printed [1] However, many printers and presses have different characteristics and do not always output the same image [2-4] and different platforms treat displayed images differently [5]. This is because monitors are based on RGB values, while presses and printers are based on CMYK values. To make things more difficult, different printers and presses have varying interpretations of the CMYK values. That is because they have their own gamut, or range of reproducible colors [2,3]. The type of paper being printed on also changes how the image is reproduced [4,6].

The Shinohara Offset Press is a two-color sheet-fed press that uses the process colors to print full color images. Sometimes the press does not print the same image as shown on the computer monitor or proof. The Xerox DocuColor 12, which also uses process colors, has some discrepancies in the output of the color of the images as well.

Color management [4] will solve this problem by profiling the press and printer. If each device is profiled, their printed products will match one another, as well as what is on the monitor, if the monitor is calibrated properly[1,5]. Each type of paper will also yield the same color values.

Background

The quality and uniformity of color in printed products is very important in today's industry. Images must match and be consistent and reliable. Color management systems help carry out this concept and reduce or eliminate any color matching problems [4]. Color management is "the use of hardware, software and methodology to control and adjust color among different devices in an imaging system" [6].

Color management tries to make color more predictable. Translating color between devices using a device-independent profile connection space and standard profiles for each device makes color more predictable. A profile describes the characteristics of a device and then a color transformation is performed by a color management module (CMM) [4]. Using the profile and CMM will result in more accurate and consistent reproduction between devices, soft proofing, gamut checking and mapping and profile embedding. These features reduce the time and cost of reproducing color.

Color Basics

The basics of color theory must be discussed to understand how color management works. Color is a visual sensation that occurs when light reflected from an object is focused onto receptors in our eyes [4]. From this, we can gather that there are three factors that affect the color of an object—the light source, the object itself, and the human eye. A color management system must take these three factors into account.

Color Theory

There are two main color theories that are the foundation of color reproduction in printing. The first is the additive color model, which is based on the primary colors of light—red, green and blue [4,6]. It involves transmitted light before it is reflected by a substrate. When red, green and blue are combined in varying intensities, they create a full spectrum of colors. When all three are mixed at equal intensities, they create white light. Computer monitors and television screens are based on the additive color model.

The subtractive color theory is the other main model [4,6]. It is based on light reflected from an object that has passed through pigments or dyes that absorb or subtract certain wavelengths, allowing others to be reflected. This reflected light is made by combining red, green and blue. When red and blue mix, they create magenta, when blue and green mix, they create cyan, and when red and green mix, they create yellow. Cyan, magenta and yellow are the resulting colors. When these three colors mixed in equal intensities, they produce black. When the process is reversed, mixing cyan and magenta creates blue, magenta and yellow creates red, and yellow and cyan form green. The subtractive color model is used in all printers and presses.

Additive and subtractive color are illustrated in Figure 1.

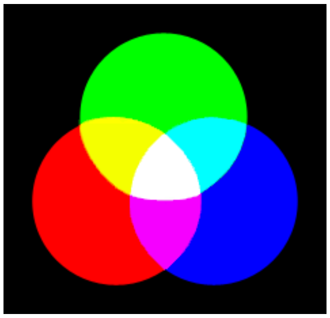

Figure 1. Additive Color Theory.

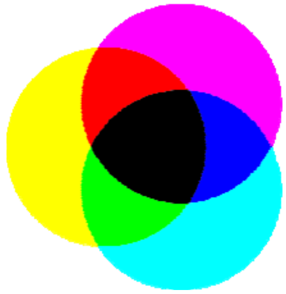

Figure 2. Subtractive Color Theory.

Color Theory

There are also color spaces that that help build the basis for color management by quantifying colors, or specifying colors by their positions in 3D space. These include XYZ, Yxy, Lab and LCH, which are specified by the International Commission on Illumination (CIE) [4]. They take into account the light source, object and human observer factors of the perception of light, so they are very closely correlated to how humans see color.

Color spaces are based on the three attributes of color: hue, saturation and lightness. Hue is the actual color (red, green, blue, yellow, etc.), saturation is the intensity or vividness, and lightness is how dark or light the color is. This can be represented in a 3D model, where the lightness is depicted on the vertical axis, saturation is shown on the horizontal axis and hue is depicted along the circumference of a cylinder.

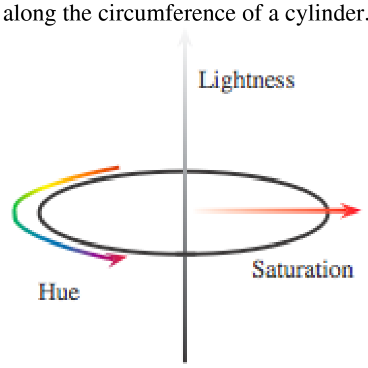

***Figure** 3. 3D Color Space Model.*

CIELAB is one of the main color spaces focused on in this project and one of the most widely used [4]. L represents lightness, and a and b represent the hue and saturation. The values represent a color's position in the 3D sphere. This way, the distance between two colors can be quantified, which is important in color management. The difference between two colors is called ΔE [4]. A small difference in color will show a small numerical difference, and a large difference in color will show a large numerical difference.

The two color models mention earlier can also quantify color, by giving R, G and B or C, M, Y and K values. However, the difference between this quantification and that of a device independent color space, such as CIE LAB, is that RGB and CMYK are device-dependent. That means that they are specific to the device that they are used. These values will be different on each monitor or press, even if they are the same make and model. On the other hand, CIELAB is device independent and the colors will be the same on every device. LAB acts as an interpreter between RGB and CMYK. An RGB monitor will be converted into LAB values and then to CMYK values to be outputted.

RGB and CMYK also produce different gamuts, or color ranges. Monitors generally can produce a larger gamut than a printer, because it is RGB and the printer is CMYK. The gamuts also vary between each device. The gamut of a scanner depends on the technology and media used, monitors depend on the composition of the phosphor and printers depend on the inks and media. Therefore, printers may not be able to output all of the colors shown on the monitor and there will be a substitution of colors.

Profiles

ICC profiles are the key to color management and help perform the tasks of converting RGB to LAB to CMYK and translating monitor gamuts to printer gamuts. Their purpose is to maintain color consistency in images viewed, displayed or printed on different devices. This is accomplished by the use of a device independent Profile Connection Space. This space is where the profile is located, between the scanner and the monitor, the scanner and printer and the monitor and the printer. It connects each device, relating each one to a central color scale.

A proof is a process that simulates the results of a press on a printer, so the results can be seen before printing thousands of impressions. The profile made for the press is applied to the image and printed on the printer. It provides a preview of what it will look like on the press, in order to identify any possible problems. This saves time and money for printing companies and customers [4].

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