Optimizing Proofing in a Digital Work Flow

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Abstract

As printers, it is important to be able to produce accurate proofs before going to press. It is not a rare occurrence that a file looks different, depending on the output device used. This poses a problem for all parties involved with maintaining the accuracy of the print. The DocuColor 12 is a digital proofing device that has been SWOP (Specifications for Web Offset Publication) certified. SWOP certified machines should be able to print test charts that will have very similar, if not identical color measurements. This paper looks to verify this certification by printing a test chart and measuring the color patches. The DocuColor 12 was used to create a new profile, which was applied to the IT8.7/3 chart and these patches measured. The charts were measured with a GretagMacbeth SpectroScan spectrophotometer. The DocuColor 12 was profiled by printing an ECI 2002 test chart and calculating the profile with GretagMacbeth ProfileMaker 5.01. The results showed that some of the colors had the same values as those specified by SWOP but some others were very different. The experimental procedure, the results and reasons for differences are discussed.

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Introduction

Color has been defined as "the appearance of objects or light sources described in terms of the individual's perception of them, involving hue, lightness, and saturation for objects and hue, brightness, and saturation for light sources." (American Heritage Dictionary, 2000) From this definition we conclude that color is subjective. What this means is that different people will see the same color in different ways. This also means that the same person will see a shirt in a store and decide that it is one color and when they get the shirt home, the color is different. This is because of the different light sources that have an effect on how humans perceive color. Because of all the different ways in which we see color, it is almost impossible to attain color control based on human appraisal alone. What this boils down to is the fact that the only way we can ever gain control over color management is to "move away from subjective evaluation of colors and use measuring instruments to give us repeatable numeric values for color."

The Munsell System

Fortunately for the Printing Industry, this problem was recognized and a solution reached. At the beginning of the 20th century, Professor Albert H. Munsell (1929) brought clarity to color communication by developing the first widely-accepted color order system to make the description of color accurate and convenient and to aid in the teaching of color. He started with a color wheel that had the different hues arranged around a circle, going through the color spectrum from red to blue then with the purples formed from the blue and red to finish off the circle. These hues were named in terms of five principal colors-red, yellow, green, blue and purple. Halfway between each of these he placed 5 intermediate colors, yellow-red, green-yellow, blue-green, purple-blue and red-purple. The result was a decimal system of color with even more subdivisions of each of the first ten colors into ten degrees around the circle. The Munsell Color Wheel is depicted in Figure 1.

As well as their hue, Munsell characterized colors by how light or dark they were, which he called the 'value' or lightness and also by how intense the color was. He called this attribute the chroma and it is also known as saturation. By arranging colors the way he did, Munsell showed that some colors, like the reds, blues and purples had wider ranges of saturation, or chroma, than others like the yellows. He also found that at full saturation, the yellows were brighter than the blues or purples. The result, therefore, was not the neat color sphere that Munsell had hoped for, with the chroma values of each hue radiating from the center of the circle, with different values represented on a vertical axis. What he ended up with was a somewhat distorted figure sometimes called a color tree. (Figure 2) The Munsell color order system has gained international acceptance and has served as the foundation for other color order systems.

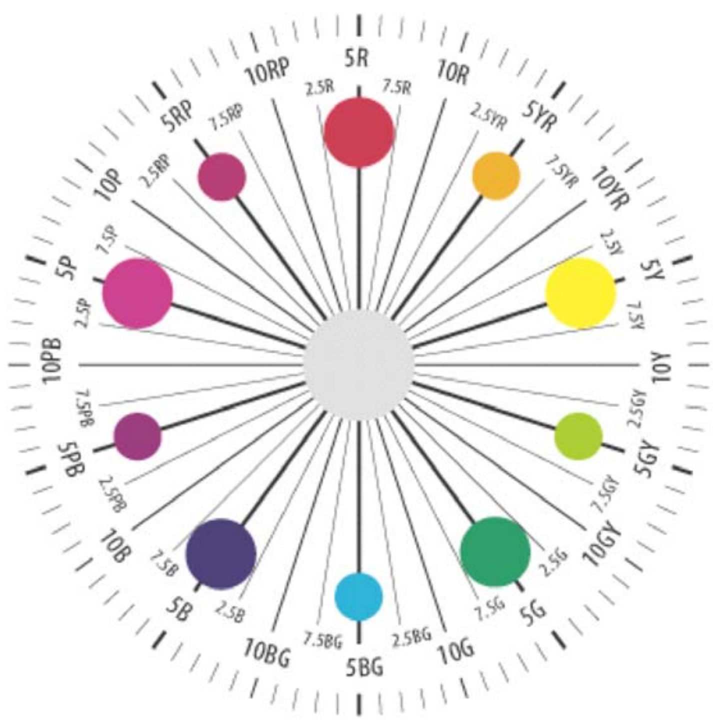

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Figure 1. Munsell Color Wheel

Today, these color measurement systems are monitored and controlled by the Commission Internationale de l'Eclairage/International Commission of Illumination (CIE). The CIE has written guidelines on how color measurements should be taken and the devices that should be used to take these measurements (CIE, 1986). Their color systems have been successful because they take into account the three basic attributes of color; hue, saturation and lightness, just like the Munsell System. By accounting for all these factors, we can be assured that the devices being used to measure color are 'seeing' the color in the same way that the human eye sees the same color. The only difference is that the device is able to give a numeric representation of the color instead of simply declaring it "blue" or "light blue." The most well known systems used today are the CIE (1931) XYZ and the CIE (1976) L*a*b.

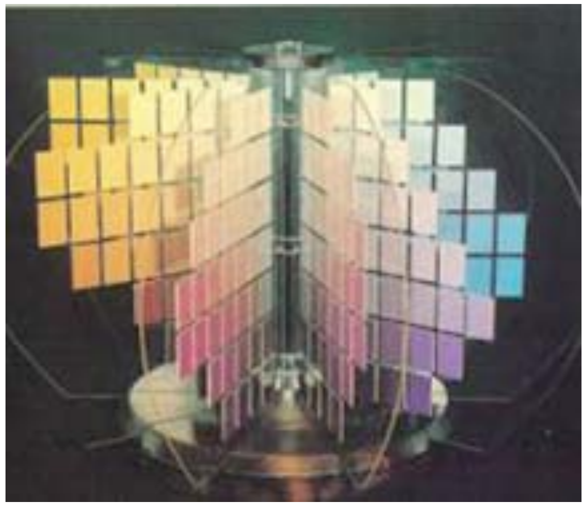

Figure 2. The Munsell Color Tree

CIE XYZ

In 1931 the CIE developed the XYZ color system, also called the "norm color system". This system is often represented as a two-dimensional graphic, which more or less corresponds to the shape of a sail. The red components of a color are tallied along the x (horizontal) axis of the coordinate plane and the green components along the y (vertical) axis. (Figure 4) In this way every color can be assigned a particular point on the coordinate plane. The spectral purity of colors decreases as you move left along the coordinate plane. While brightness is not taken into consideration in this model, it is used to derive the other commonly used color spaces such as Yxy and LAB.

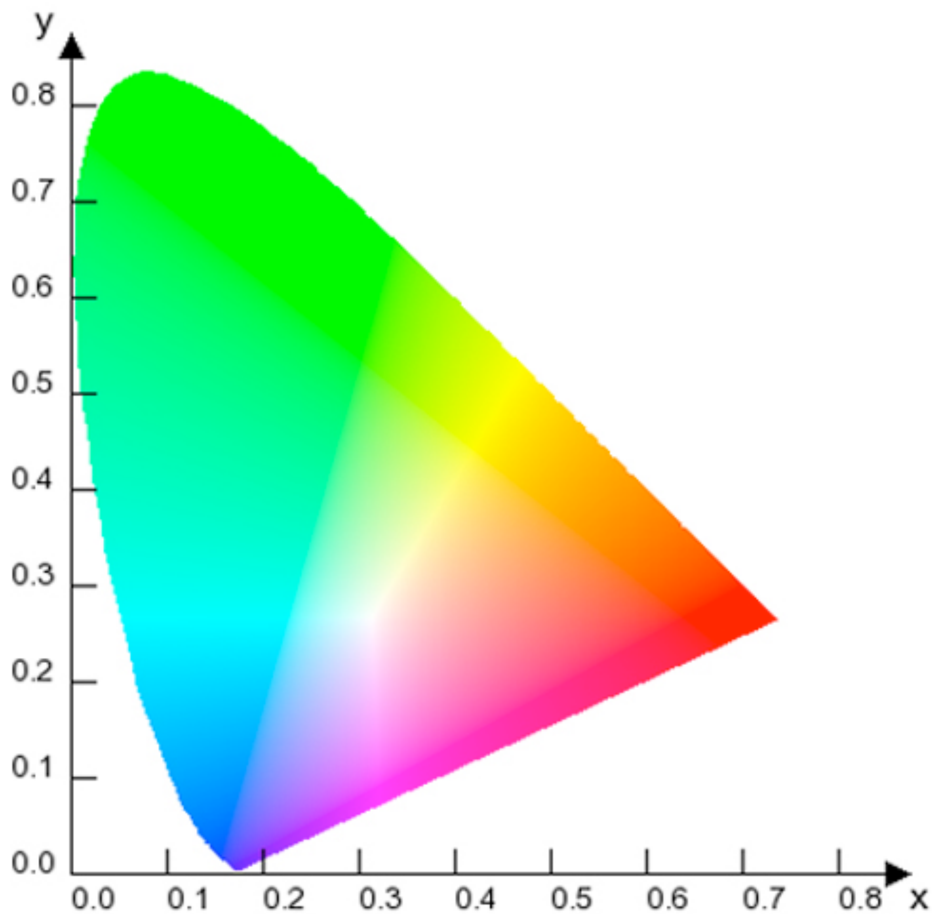

Figure 4. CIE XYZ Diagram

CIE L*a*b*

CIE L*a*b is an improvement of the CIE XYZ color model. In this three dimensional model, (Figure 5) the color differences correspond to distances when measured colorimetrically. The a* axis extends from green (-a) to red (+a) and the b* axis from blue (-b) to yellow (+b). The brightness (L*) increases from the bottom to the top of the three-dimensional model. Colors are represented by numerical values. In comparison with XYZ, CIE L*a*b* colors are more compatible with colors sensed by the human eye. With the CIE L*a*b*, the color luminance (L), hue and saturation (a, b) can be revised individually; as a result, the overall color of the image can be changed without changing the image or its luminance. Because CIE L*a*b* is device independent, when RGB is changed to CMYK, or CMYK is changed to RGB, the software requires the change to be first processed via the CIE L*a*b* color model.

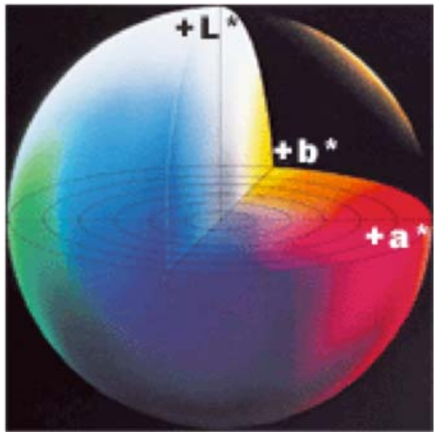

Figure 5. CIE LAB Diagram

With so many ways of representing color, it is easy to see how vast differences can occur when transferring files from device to device or when simply trying to get an accurate proof.

SWOP Certification

In order for a manufacturer to be able to say its off-press proofing device is SWOP (2005a) certified, several steps need to be taken. First, the manufacturer must submit a SWOP (2005b) Application Data Sheet (ADS) and all representative proofs to SWOP to achieve certification. SWOP representatives check proofing systems entered for certification against the supplied ADS for quantitative conformance and determine the acceptance of each system's visual match to a SWOP Certified Press Proof. An ADS should say how the proof was produced and include any other relevant information.

"The Application Data Sheet presents the manufacturer's recommendations including sequence, colorants and substrate, which when followed, result in appropriate colorimetric (CIELAB) and densitometric data that provide the best match to SWOP Certified Press Proofs (SWOP 2005b). Additionally, SWOP has established a method to verify a proof's conformance to the manufacturer's Application Data Sheets." It should be noted that just because an off-press proof is made in conformance to the manufacturer's SWOP Application Data Sheet does not mean that a SWOP certified proof has been made.

Experimental

The aim of this experiment was to see how closely a Xerox (2005) DocuColor 12 digital printer was able to print colors with values close to those obtained by

SWOP. The tests were performed using the DocuColor 12 in the Print Lab in the Department of Paper Engineering, Chemical Engineering and Imaging at Western Michigan University.

The first step in the experiment was to build an ICC profile for the device that we could apply to the IT8/7.3 test charts used to compare with ANSI (1996) TR001. Using #2 Light Weight Coated (LWC) paper, we printed the ECI 2002R chart three times and used GretagMacbeth ProfileMaker 5.01 and MonacoPROFILER 4.5 software to build the profile.

The next step was to apply our profile to the IT8.7/3 chart and also the SWOP profile built into the printer and again, printed each three times. In each instance, the charts were measured using a SpectroScan spectrophotometer.

Once all the color values for the IT8.7/3 charts were obtained and recorded, the original SWOP color values (TR001) were downloaded and a comparison made of the L*a*b values.

Results and Discussion

When producing color proofs, accurate reproduction of colors is vital. Simply measuring the charts was not enough. The data were entered into a spreadsheet and comparisons of the L*a*b values made both in Microsoft Excel and Measure Tool. The data spreadsheets are located in the appendix. Along with this comparison, the ΔE values of the TR001 data was compared to those of the test chart with out profile and also the SWOP profile from the DocuColor 12. ΔE is calculated by the following formula:

$$\Delta E = \sqrt{(L_1 - L_2)^2 + (A_1 - A_2)^2 + (B_1 - B_2)^2} \tag{1}$$

ΔE for our profile was calculated and found to be 4.23. ΔE for the SWOP profile, however, was found to be 6.59. This poses a problem because what this means is that color is not being printed correctly, or, rather, as it appears to those who will print under SWOP certified conditions. The value using the profile is much better than using the SWOP setting on the printer, but not as good as seen in previous studies for other digital devices (Sharma, 2004, 2005, Chovancova, 2004, 2005).

Using measure tool, we found that the patches that were different on the SWOP chart were randomly scattered across the chart. The patches that differed on our chart, however, were concentrated on the darker areas of the chart. This is illustrated in Figures 6 and 7.

Conclusion

Based on the results we obtained from the experiment, we can safely assess that the DocuColor 12 does not print to SWOP's targets. The reasons for our results vary. It could be an issue with the paper we used or with our method. It was brought to our attention that the SWOP measurements were taken against a black backing and that could have had something to do with the differences we observed. In short, further analysis is needed in order to determine what exactly caused the difference.

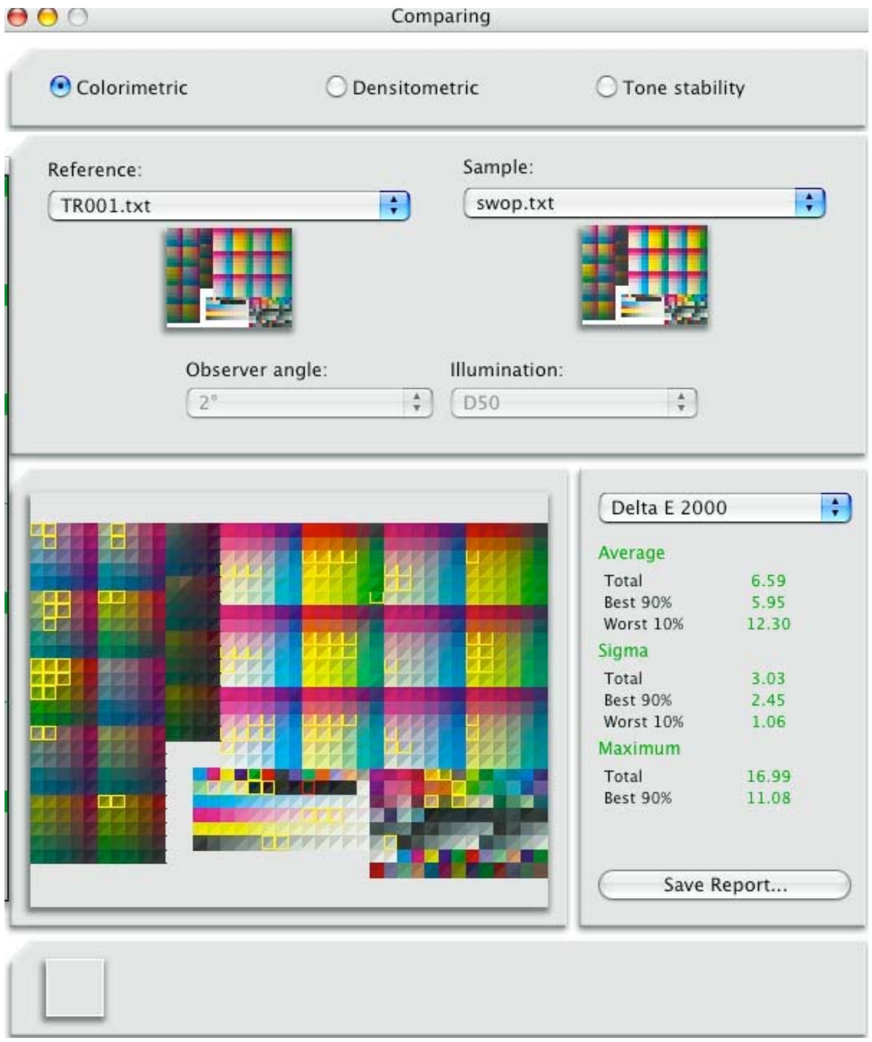

Figure 6. Graphical depiction showing patches of IT8.7/3 chart printed in SWOP mode on the DocuColor 12that have large ΔE values relative to TR001.

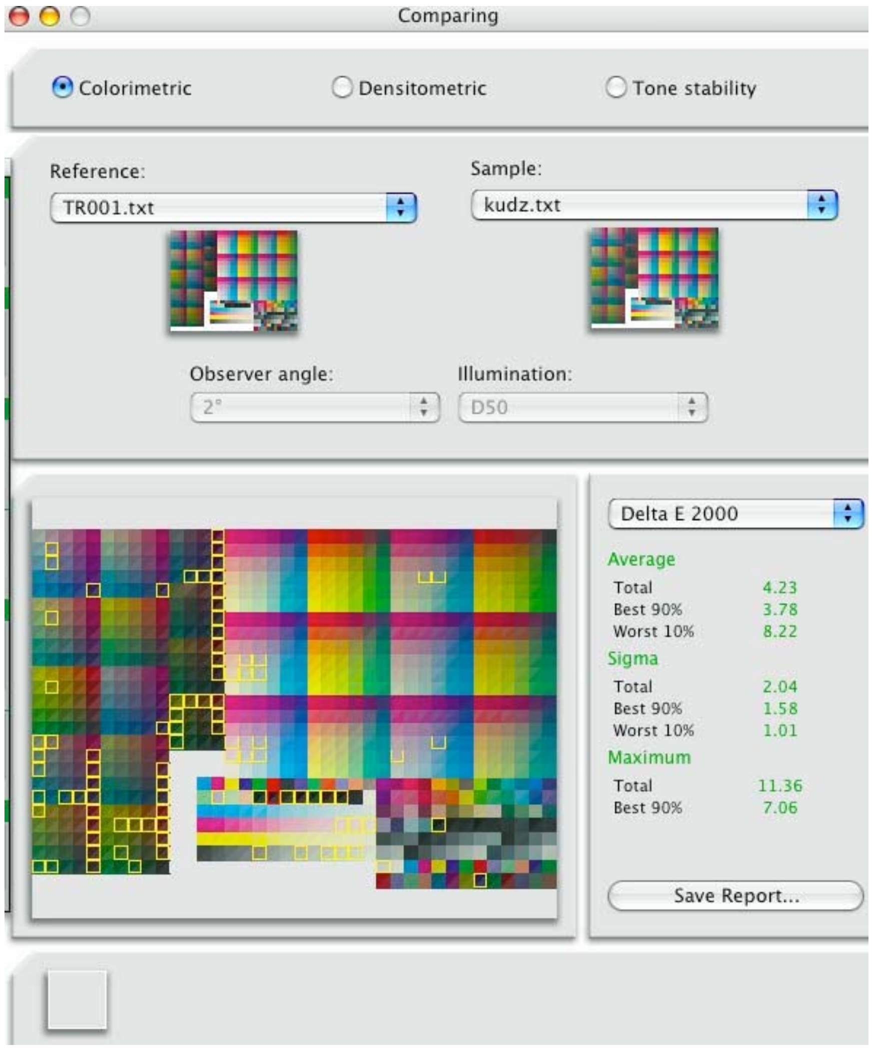

Figure 8 Graphical depiction showing patches of IT8.7/3 chart printed using DocuColor 12 profile that have large ΔE values relative to TR001.

Acknowledgement

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SWOP

2005a http://www.swop.org.

2005b http://www.swop.org/certification.html.

Xerox

2005 http://www.xerox.com/go/xrx/equipment/product_details.jsp?Xcntry=USA&Xlang=en_US&prodID=DC12CP&cat=Product+Taxonomy%2fProduction+Systems%2fDocuColor.