

Standard Color Spaces and ICC Color Management

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Introduction

The framework for profile based color management emerging from the International Color Consortium has generated a *de facto* methodology for representing, interpreting and converting digital values that encode color information. While providing a sound theoretical basis, this approach has encountered obstacles when applied to practical implementations, especially in high-end graphic arts production. In this paper we describe some of the issues and how they might be alleviated with the adoption of standard device characterizations that simplify and facilitate the color management process.

A Few Scenarios

To begin, let's imagine a few scenarios that represent current paradigms in print reproduction. Today's publication industry is driven primarily by requirements for high-quality advertisements. Advertisers want ads to be published to the strictest of color quality standards but they also want the flexibility that a digital workflow will bring. Imagine a large offset magazine job, to be produced in New York and printed in California and South Carolina. In today's workflow, color data moves over many enterprise boundaries. For example, the prepress service gathers the "art" from an ad agency and converts it directly into a CMYK color space for an ad to be printed by perhaps three different printing companies. Preferred editorial or quality adjustments are done with close regard to the ultimate CMYK rendition that will be printed. The prepress service, through experience, has learned how to make these CMYK color adjustments using, as guidance, a proof that simulates the specific print characteristics representative of publication printing. (In this country SWOP[1] has provided the widely accepted description of this printing characteristic.) At printing plants press operators are expected to maintain their printing processes such that the finished product can be made to be a close match to the proof. In this scenario we see two realms of color management: at prepress, where color is adjusted under the guidance of a standard output characteristic; and at press, where reproduction to that standard characteristic must be maintained. It is important to realize that the dynamics of the publication industry demand this delineation and that color management, ICC or otherwise, will be most successful if it can serve the needs of this framework.

As a contrast, let's imagine an Internet magazine, produced in San Francisco with content from New York, Chicago and Los Angeles. The magazine's web site is rich in graphics and digital images. The reporting staff makes heavy use of digital cameras in the field and desktop scanners for other content. In this example, there is no traditional prepress department through which all content flows. Each site has different digital camera and scanner hardware. In addition, the large staff of freelancers all have different imaging equipment. Because of this, the production facility has instructed everyone to attach ICC profiles or indicate that the file is sRGB.

In each scenario, different workflows are used and they seem to have different needs for color management. The people in each scenario have set up their workflow in order to be productive. What happens if these examples are merged and the *same* magazine is published online and in print? Further, let's assume that, while the structure of the magazine changes, a great deal of the content is the same. How can the needs of both groups be addressed with a single color management framework?

The example scenarios show that the field of color management needs at least two different color management workflows. On the one hand, the graphic arts industry traditionally has fixed the working color space as early as possible in the workflow. This requires a "highly tuned" prepress data stream where the originator of the CMYK data has knowledge of the destination printing process. On the other, the Internet and other media distribution networks have produced a need for the data to remain flexible and repurposable. The originator of color data may keep the data in RGB space with the intent that the is data to be used on many different media. These differences are the root of many conflicts in the color management industry when those with one need propose a solution that directly interferes with those having another need. This paper will describe how both needs can be addressed within the current ICC framework and with the future ICC baseline work.

The Graphic Arts Workflow

As presented in our example, the traditional graphic arts workflow consists of two major production areas: prepress and print manufacturing. Major prepress functions include design, capture, editing, assembly and proofing. Efficient attainment of desired color in prepress depends on accurate capture followed by aesthetic adjustment that is guided by a proof simulating the ultimate output. Print manufacturing must then produce color that matches the simulation proof.

In many markets, such as publication advertisements, the requirement of reproducing an ad identically across a multitude of printers suggests the need for a standard output color characterization. In traditional film based workflow, the specifications known as SWOP[1] have provided a set of color reproduction characteristics that have improved the consistency of advertising for publications during the last 25 years. In essence SWOP provides a kind of standard characterization by specifying CMYK primary hues, gamut, tone reproduction and neutral balance. Now a more precise characterization has been published as an ANSI Technical Report (ANSI/GCATS TR001)[2] that provides a full colorimetric characterization relating CIE color values to CMYK variables for SWOP conditions. It is important to remember that the TR001 not only characterizes the ink and substrate, and thus the gamut of SWOP printing, but also other physical parameters that compromise the overall reference print condition.

Since SWOP printing covers only one segment of printing (Web Offset Publications), it has been suggested that other standard CMYK spaces be defined, perhaps as many as six.[3] We believe that a selection of four CMYK spaces is suitable. As an analogy, sRGB already exists as a standard RGB space. Many have presented the problem of "too many RGB spaces"[4] or why "one is better than another".[5] The same problem exists that "too many" CMYK spaces should be avoided. Too many spaces defeat the purpose of having a standard. The four proposed spaces would be based on the following substrates, Newsprint (based on SNAP printing conditions), Uncoated/Super Calendered (Sunday Supplements), Coated Publication (SWOP based), and Premium/Commercial (based on the highest quality commercial printing). The differences between each of these are primarily in gamut and ink characteristics obtainable with the different grades of paper stock. The basis for this proposal is that the difference in color gamut, from Newsprint to Commercial/Premium, would seem to be adequately delineated into four ranges. Since the main differences are due to the substrate, it seems to be possible to extend the reach of these four standard spaces algorithmically by adjusting tone scales, paper white and dot gain curves for any substrates in between. This concept suggests research for future work.

A shop could use ICC profiles and a specific CMM to convert incoming RGB to a standard CMYK space or the shop could choose to retain the data in its raw RGB form and simply attach the output profile indicating the file has been prepared for output to that standard space. This approach allows the data to be repurposed for other applications, (e.g. Web Sites) while retaining information that preserves the intended CMYK rendering on later output. This approach has been called Virtual CMYK.[6]

Virtual CMYK refers to color data that is destined to become standard CMYK data, but is not yet in that color space. For example, an RGB image that is proofed on a TR001 color proofer, may still be in RGB space, but it is intended for CMYK rendering and has been previewed through the use of profiles and a consistent CMM. This allows the color data to be moved about or used in RGB or different CMYK spaces, maintaining the link to its ultimate destination through profiles. When using the virtual CMYK concept, it is important to remember that the rendering decisions must still be done early in the process. This requires either a prepackaged transformation, such an ICC device link profile, or a CMM with consistent processing. In the case of Virtual CMYK, the goal of the CMM is to reproduce the color exactly as specified, not to "improve" it or make it "better".

Advantages of Using Standard CMYK Color Spaces

Use of standard CMYK characterizations in graphic arts can simplify color management implementations much as the sRGB standard does for display media. It can also help define baseline operations that provide consistency where required. Following are a number of advantages that serve the color reproduction needs described above as well as the efficiency and reliability requirements found in most high-end graphic arts environments.

1. Simplified profile management in prepress. Characterization and profiling of output devices, when carried to the extreme, is not only impractical for print manufacturers but also leads to an impossible profile management problem in prepress. The use of output profiles based on just a few sets of standard characterization data would vastly simplify prepress operations where output simulation and conversion are required.
2. Simplified proofing methodology. Standard output characterizations would motivate proofing vendors to provide high quality target profiles representing these characterizations in their systems. This would add value to their products in a number of ways. First, prepress operators would not have to create custom profiles for all their proofing devices. Secondly, the proofing operation would improve in quality and simplicity since concatenation of a particular press profile with a source and proofer profile is not required. Finally, separate workflow for proofing and final data output is not necessary since the proofer acts as virtual output device.
3. Clarification of responsibility between prepress and print manufacturing. Standard output characterization helps provide a clear separation for allocation of color

reproduction responsibility. Prepress responsibility is fulfilled if the proof accurately simulates the intended characterization. Print manufacturing responsibility is fulfilled when the final print product matches a valid proof.

4. Stabilizes input to print manufacturing. Receipt of production data that has been targeted to a small number of standard characterizations simplifies and normalizes the communication of color into the manufacturing process. Printers can more effectively provide the customized color management required to link their output processes to well defined standard characterizations. This also serves the needs of customers requiring matching output among a variety of different printers.

Two Methods, One Framework

An ICC Baseline framework has been proposed.[7] This system includes a number of improvements and clarifications to the ICC model. The new system includes a color appearance model, a profile making specification, an standardized CMM processing model, and a standard gamut mapping algorithm. These elements constitute a baseline system, that is, a system which when followed, guarantees a particular result. This direction is seen as a means to guarantee interoperability between users of diverse equipment or with different applications.

While the baseline algorithms should produce enough quality for most applications, the very high requirements of the graphic arts industry may require that alternative methods be used. The ICC framework is not exclusive of these needs, in fact, consistent CMM behavior is a requirement for the graphic arts.[8] Given that the ICC will provide a consistent CMM specification, how can the graphic arts industry extend the ICC baseline to satisfy their workflow needs?

The virtual CMYK system described is entirely complementary to the ICC framework, just as is the sRGB system. Each virtual CMYK space would be specified, not as a default, but as a reference to the printing conditions desired. This allows shops that are using the ICC in their prepress workflows to work with the virtual CMYK workflow.

From a manufacturer's viewpoint, digital printers can be characterized as digital proofers simply by including an ICC profile that can be used to map from a standard CMYK space to the printers device space. Alternatively, similar to those manufacturers who have begun to market sRGB printers, the proofer manufacturers could begin to market CMYK printers that could directly use data in a standard space, much as many SWOP-based products do today.

Given a small number of standard RGB and CMYK spaces, it would be possible to define a baseline transformation between these spaces. This would facilitate interaction between the two worlds. For example, the Internet publication shop mentioned earlier, could use sRGB in the web version of the magazine. When they needed to repurpose some of their print content for the web, they could use a standard CMYK to sRGB transform and get consistent results. Conversely, the print version could use content from the web version if an sRGB to standard CMYK transform was used.

Conclusions and Recommendations

Graphic arts production requirements offer somewhat specialized challenges in the world of color management. Apart from requirements for workflow simplicity and reliability, the color matching scenario for certain applications is distinct from the "best output" concept of idealized device independent processing. Standard device characterizations can provide the basis for consistency required in these situations. This simplifies prepress color management by providing a common target for proofing and output. It also helps normalize input to the print manufacturing process where conversion for specific output devices is more appropriately controlled.

We have proposed a framework for standard CMYK color spaces that is complementary to the ICC framework and the sRGB workflow used in Internet publishing. We believe that this system is not at odds with the goals of a baseline ICC system and that adoption of this concept will further grow the scope and usability of the ICC system.

References

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