Cross-Platform Image Fidelity

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Abstract

As color input, display and output devices become prevalent, the need for managing color becomes greater and greater. Color management refers to tools that support color matching, editing, preservation and storage. Color management offers the means of transmitting color images and documents containing color across local and wide area networks and between diverse operating systems and applications while maintaining the fidelity of the colors of the original image or document.

Introduction

Color management refers to tools and solutions designed to facilitate the use, operating and maintenance of color in a world of diverse applications and operating systems. In this presentation, the focus is on cross-platform color management and the emerging industry efforts to forge a standard to manage color in different applications and across different operating systems.

The fundamental problem to be solved lies in the device dependent nature of color devices. That is, color is specified in RGB or CMYK without a standardized reference point to define the objective meaning of RGB or CMYK. This presentation reviews the problem of device dependence and the options to create device independent color images and focuses upon emerging solutions to provide high levels of color management across applications and operating systems. Particular attention will be applied to the InterColor Profile Specification and the directions adopted by the major operating system vendors and application developers for those operating systems. The directions taken by Microsoft, Apple, Sun and SGI are critical to the attempt to evolve an industry color management standard and will be described as key components in the attempt to derive an industry standard for cross platform color.

A Color Matching Solution - Apple's ColorSync™

To a degree the color management solutions such as ColorSense, Fotoflow, EFIColor and Color Composer came about due to a lack of color management support at the level of the desktop operating system. This lack is changing rapidly as all of the major manufacturers of operating systems, with the exception of IBM, have announced color management as an integral part of the OS. As an example of providing system level color management solutions, Apple has designed a series of extensions to the QuickDraw and QuickDraw GX graphics architecture's of the Macintosh Operating System. Because Apple wanted to provide an architecture where third party developers could add value, ColorSync utilizes a facility know as the Component Manager. This was developed in conjunction with QuickTime™ to link a series of Apple or third party color management resources and utilities.

Because Apple's ColorSync served as the model for color management on other operating systems, a more detailed review is in order to understand the emerging cross-platform portability solutions.

The architecture of ColorSync in the existing QuickDraw world provides three important features;

1. System level support for color matching
2. Support for existing applications
3. Opportunities for third parties to add color matching modules

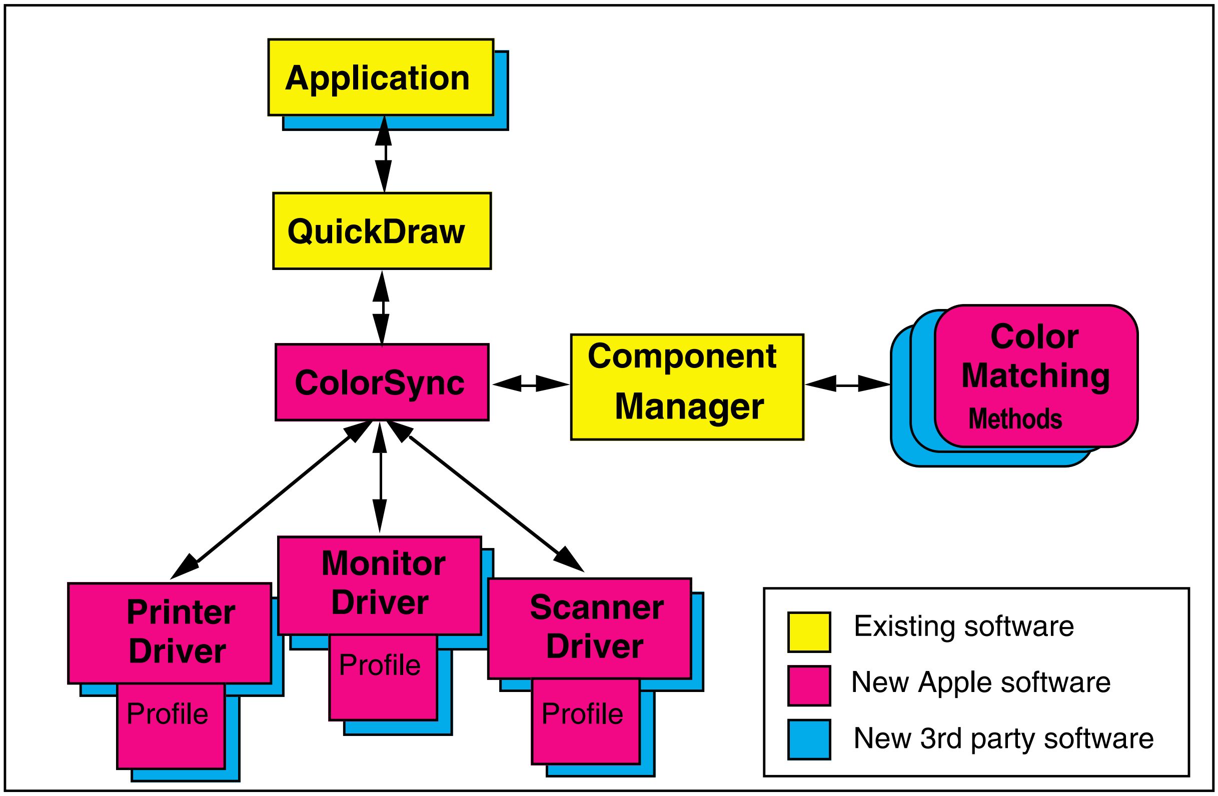
To create a device independent color definition while maintaining compatibility with QuickDraw (which is RGB based), Apple used it's own Color High-Resolution RGB monitor as the default system profile or space (the user can define the system profile by selecting the monitor he or she is using assuming a profile for that monitor is installed). The source RGB data can be converted to CIE XYZ based on the source profile to provide a device-independent definition of color on the Macintosh. Once there is a device independent description of a device, we can translate the capabilities of any input device to those of any output device.

Device Profiles and Drivers

Because ColorSync uses CIE XYZ, devices can be characterize in terms of that color space. These characterizations are called profiles. They are essentially a description of the color capabilities of a specific device in terms of the CIE XYZ color space. Since all devices are described in terms of a common space, comparisons can be made between any pair of ColorSync devices without having to be compared to each other.

Color Matching with ColorSync Color Matching Methods

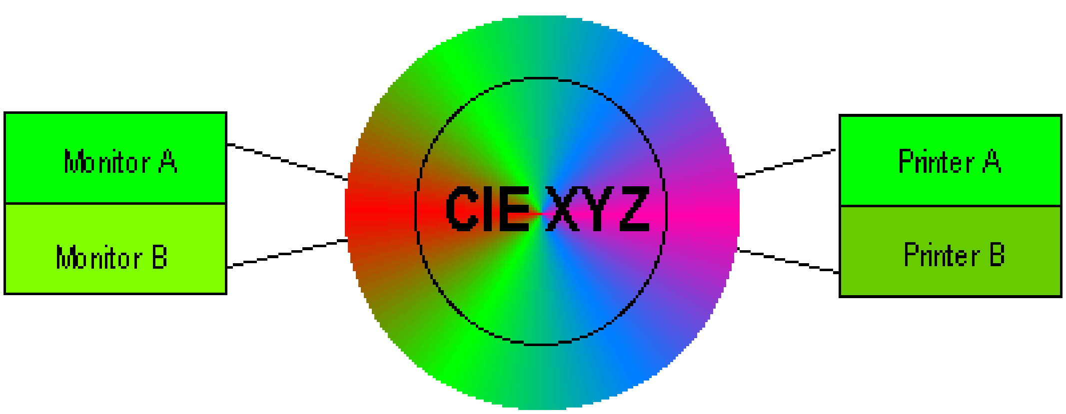
The final key to color matching is converting from one color space to another and giving the best possible match when the exact match is not possible. For example, a scanner and display may display a very vivid red, but a



given printer may only provide a pinkish red. When a color is not available, a method can be used to determine the "next best" color. The schemes for determining the best approximation are called the CMMs.

Other companies such as EFI, Kodak and Agfa are developing other CMMs that are table driven. This means that they have large color look-up tables that provide the next best color. These tables can give superior results and can be faster but require much more memory and a separate table for each scanner, display and printer combination. If users require better color matching capabilities and have additional RAM/disk space, these alternative CMMs can be purchased from these third parties. Adobe offers color rendering dictionaries (CRDs) which translate from the device's native color space to Adobe's Level II PostScript Color extensions.

Apple has already announced ColorSync 2.0 which will be a much more robust and extensive operating system extension. In particular ColorSync 2.0 will be an integral part of Apple's new graphics module, QuickDraw GX scheduled for release in System 7.5 in April of 1995.



Microsoft's Independent Color Matching (ICM)

Microsoft is pursuing a similar solution to Apple's ColorSync with it's Independent Color Matching (ICM) module as a key component of Windows 4.0 (Chicago). As with Apple's solution, Microsoft will provide an API for developers that allows applications to call on color processing facilities directly from applications. Microsoft has teamed with Kodak for the color matching capability and will provide a default color matching solution developed by Kodak for Microsoft. The default is tailored for high speed and small memory requirement so that it will work on all Windows systems irrespective of RAM size. The default engine provides an 8-bit transform which will provide adequate color matching for a typical users. ICM does provide for the addition of higher accuracy color matching modules which can be supplied by Kodak. These drop in replacements for the default module offer full 32 bit capability and are derived from the Kodak Precision Color Matching capability.

UNIX Color Matching

On the UNIX side of the operating system world, SUN Microsystems has aligned itself with Kodak in a similar move to Microsoft. SUN will extend it's Solaris operating system to support color matching modules supplied by Kodak. The system will be extensible in that color matching modules from other suppliers such as EFI, Agfa as well as Kodak can be used to replace the default matching method. SUN will be supplying a Software Developers Kit (SDK) to their developers which will provide the necessary APIs to manipulate device profiles and tag color files.

While SGI has not announced the details of their color matching solution, it appears that it will be very much like Apple's ColorSync. In fact, it may use Apple's proprietary color matching method as the system default.

Cross-Platform Color Portability: InterColor™ Profile Format

With the major operating system vendors offering device independent color support, the problem of cross-platform color portability still remains. With all the different matching algorithms and proprietary profiling formats, moving a file created on a Macintosh to Windows or a particular version of UNIX, is a formidable task. In order to resolve this problem major vendors of operating systems and vendors of color matching solutions began a series of meetings under the auspices of FOGRA, the German based publishing consortium, in the fall of 1992. The goal of these meetings was to reach agreement on a standard profile format which could be supported by all operating systems and used by the makers of color HW products to profile their devices. Apple offered it's emerging ColorSync 2.0 profile format as an option. After over a year of meetings and extensive negotiations in which specific extensions and modifications to the ColorSync 2.0 profile format were added or modified, the group accepted ColorSync 2.0 as the profile format of choice. The companies formed a consortium, originally called the ColorSync 2.0 Profile Consortium, to drive and maintain the format. The original members and adopters of the format were Apple, Microsoft, SUN, SGI, Taligent, Adobe, Kodak and Agfa. The significance of this action is far reaching. With each of the major operating system vendors supporting the same profile format, device manufacturers need supply only a single color profile for their devices. In addition the vendors supplying value added color matching capability all will call the same profiles.

More recently the ColorSync Profile Consortium has opted to name the profile format the InterColor™ Profile Format in order to avoid confusion with Apple's specific color management solution. The consortium has adopted bylaws and established itself as a legal, cross corporate forum for color management. During the formative stages of the consortium development, Apple Computer chaired the consortium with Michael Stokes of Apple serving as the first chairman. Currently, the chairman is Todd Newman of SGI. SGI has offered it's extensive experience with various UNIX consortia to help establish the InterColor Consortium.

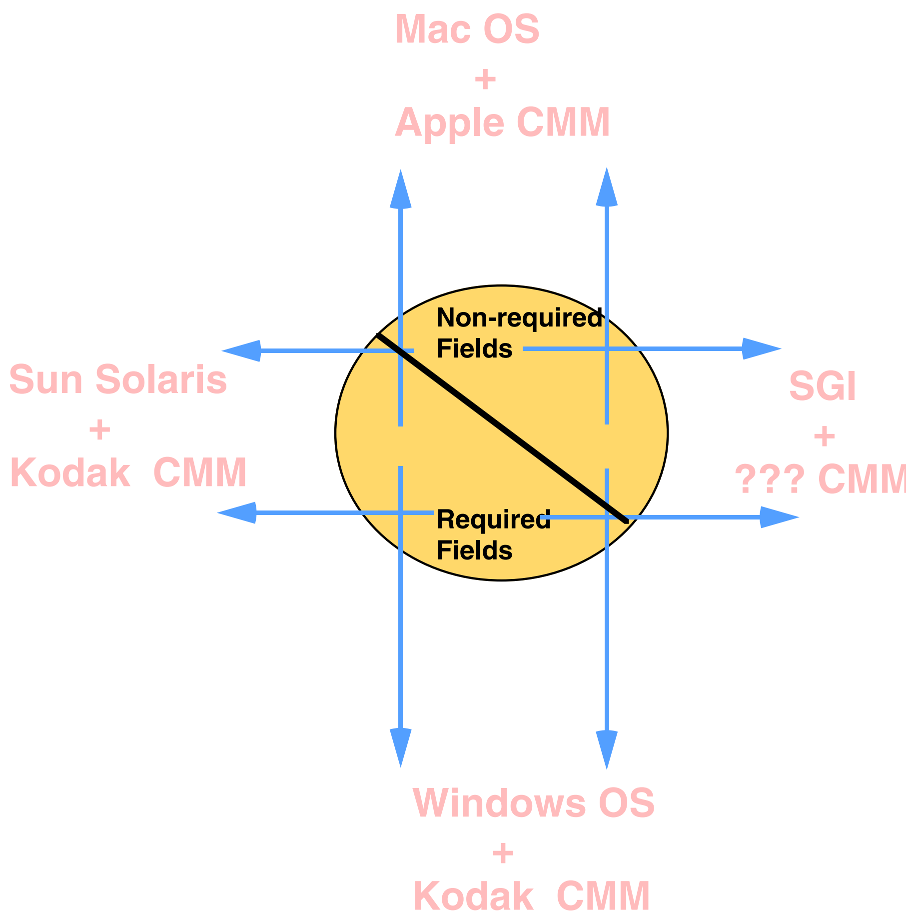
In essence the InterColor Profile Specification describes the necessary transforms between the native color rendering space of a given device (i.e. RGB for a Display Monitor or Scanner and CMYK for a Printer) and a series of device independent color spaces. Monochrome devices capable of 8 bit or greater grayscale can be profiled within the InterColor Profile as well. The specification recognizes three classes of color spaces:

- CIE device-independent color spaces:
  - CIEXYZ 16 bit per component
  - CIELab 16 bit per component
  - CIELab 8 bit per component
- RGB device-dependent color spaces:
  - Device RGB
  - HLS, HSV
  - GRAY
- CMY(K) device-dependent color spaces:
  - CMY, CMY(K)

The basic notion of the InterColor Format is that of tagging images with specific device information so that the image can be rendered on any device following the originator's rendering intent. The device tags for into three specific categories: required data, optional data and private data.

Required fields or data are required of all HW vendors as the basic profile descriptors of their devices while the optional fields add additional information about specific device characteristics. The private or non-required fields are accessible only by the vendor owning them. These provide the "secret sauce" for their product. The model is shown in the following graphic.

An important element of the InterColor format is the notion of embedded device profiles. The format outlines the requirements for the file headers and formats



to carry profile information with images or for multiple images within compound documents. Currently the PICT, EPS and TIFF formats are supported. In future releases, additional formats will be supported.

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