

## **CMS for Digital Photography, A Case Study**

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### **An Abstract\***

#### *Introduction*

There are a number of technology advancements which prompted this study: (1) multi-mega pixel digital cameras are abundant and affordable; (2) RGB-based digital printers require less user skills to yield good print quality; and (3) ICC-based color management technology has been improving since its inception in 1993. This study was an attempt to find out if ICC-based color management offers distinct advantages over a legacy-based digital imaging workflow.

To carry out the study, the difference between a legacy-based workflow and a CMS-based workflow should be differentiated. In a legacy-based workflow, the user pays little attention to device calibration and profiling. A typical scenario in a legacy-based workflow is that (1) an image is captured by a digital camera and downloaded to a computer, (2) the image is adjusted by the user and output to a printer, (3) the digital file is further tweaked in the image editing software based on the visual feedback, (4) the tweaked file is sent to the printer. The desired image quality eventually is achieved after several such iterations and is a function of the user skills.

In a CMS-based workflow, the user has to calibrate all imaging devices used and make sure that these devices stay in calibration. A typical scenario in a CMS-based workflow is that (1) an image is captured by a digital camera and downloaded to a computer, (2) the image is converted from the camera RGB space to the internal RGB space of the image editing software, (3) Image-dependent adjustments, such as cropping, image size, spatial resolution, sharpness, etc., are performed; (4) the image is converted from the internal RGB space of the image editing software to the printer space and output to a printer. The desired image quality depends on the proper use of the CMS technology and less on the user skills.

#### *Experimental*

The objectives of the study was to compare image quality from digital photography to RGB-printer under two digital imaging workflows: legacy-based and CMS-based. We define image quality in two aspects: reproduction quality and picture quality. Reproduction quality is the visual assessment of the image quality in relation to a reference, e.g., a printed image of an oil painting in comparison to the original painting. Picture quality is the visual assessment of the image quality with the observer's own criteria as to what's pleasing.

Key technologies used in the study include a Kodak DC290 digital camera capable of producing more than 2 mega-pixel RGB images, a Mac G3 with a 21" Studio Display color monitor, Photoshop 5.02 capable of ICC implementation and image adjustments, Epson SP5000 RGB-printer. In addition, a number of ICC-based color management technologies were used for device calibration and profiling. Among them, Kodak Colorflow Profile Editor was used to build profiles for the digital camera; Colorflow Profile Editor was also used for printer profiling along with GretagMacbeth's SpectroScan; OptiCal 3.0 was used for monitor profiling along with X-Rite's DTP 92 colorimeter.

To test for reproduction quality, a 2-dimensional oil painting (Halftone Process) and a three-dimensional still life scene (Yarn) were photographed. It was decided that the initial reproduction plus two iterations (labeled as A, B, and C) are allowed for the legacy-based workflow. For the CMS-based workflow, only the initial output using perceptual rendering intent (labeled as D) is allowed.

Paired comparison method was used to collect psychometric data from 20 observers. All 20 observers are college students major in either photography or printing. They were asked to select one of two images (A vs. D, B vs. D and C vs. D) which matched closer to the original painting or scene under graphic arts standard viewing conditions.

Figure 1 summarizes the design of experiment used in this study. Raw digital images captured by Kodak DC290 was the common starting point for both workflows. The authors were experienced ICC CMS users and Photoshop users. The entire experiment was carried out in a well-controlled laboratory environment at RIT School of Printing Management and Sciences.

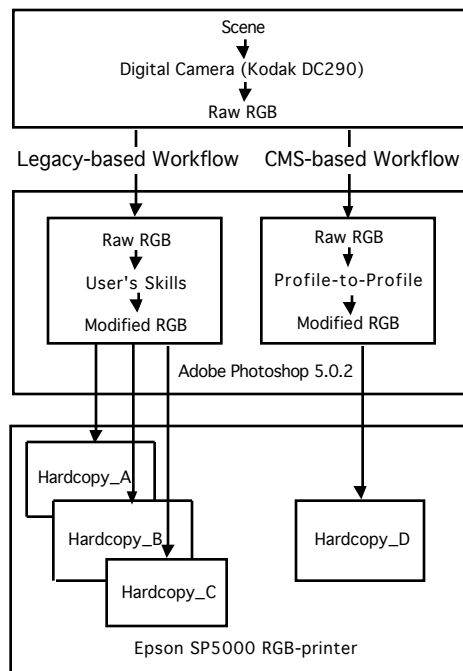


Figure 1. The experimental design conducted in the study.

To test for picture quality, four digital images with memory colors (broccoli, school bus, fruits and building) were prepared. In this case, only the images from the third iteration of the legacy-based workflow and the initial output from the CMS-base workflow were compared. The same 20 obersevers, made up by college students studying photography and printing, were involved the paired comparison.

### Summary

Due to the difference in judging criteria, the study shows that legacy-based digital imaging workflow can produce pleasing images as good as CMS-based workflow. But ICC-based CMS outperforms legacy-based workflow in matching the color appearance of the source images. This is a welcome feature in direct mail catalogs whereby printed images need to match the appearance of the merchandise closely.

It's strategic that device-dependent variables are accounted for prior to addressing image-dependent variables. Legacy-based systems fail to recognize this point by addressing both sets of variables via image adjustments. On the contrary, CMS technology separates device-dependent parameters from image-dependent variables. By adopting CMS-based workflow, it can produce consistent image quality from digital photography to color hard copy without iteration.