

Indigo Light Inks: Raising the Bar for Image Quality

Kok-Wei Koh and Ehud Chatow

Hewlett-Packard Laboratories, Palo Alto, California

Abstract

With the introduction of the original 6-color Photosmart Photo Printer in 1997, HP took inkjet image quality to new heights and ushered in a new era in home photo printing. The addition of light dye-load cyan and light dye-load magenta inks increased smoothness and reduced grain, resulting in photo quality prints that rivaled or surpassed that of traditional silver halide prints. A decade later, HP is poised to do the same to the digital publishing world with its recently introduced HP Indigo Light Cyan and Light Magenta inks for the HP Indigo press 5500.

In this paper, we reflect back on the innovations that Hewlett-Packard has brought to the field of photo quality inkjet printing over the past 10 years, and how we are leveraging many of these innovations into the realm of digital publishing.

As a case study, we describe the process of creating a high quality photo book, a Joel Meyerowitz catalogue of vintage color prints, which was produced for the photographer's exhibit at the Edwynn Houk Gallery in New York in April to June 2006. In this instance, a 7-color HP Indigo press 5000, equipped with standard process CMYK inks plus light cyan, light magenta, and Pantone Cool Gray 9C was used. All text was printed using the gray ink, while images were reproduced using 7-color process CMYKmg on the front and back covers, and 6-color process CMYKcm inside.

Introduction

In 1997, Hewlett-Packard demonstrated the benefits of adding low dye-load light cyan and light magenta inks to an inkjet printer when it released the 6-color Photosmart Photo Printer. Since then, HP has continually pushed the envelope of image quality with the introduction of the 8-color Photosmart 7960 in 2003, which added two shades of gray for creating outstanding black and white prints, the 9-color Photosmart 8750 in 2005, which added a blue ink for expanded gamut, and the recently-introduced 12-color Designjet Z3100 in 2006, which added even more primaries along with a gloss optimizer and separate photo and matte black inks for outstanding quality and flexibility across a wide range of media types.

With the recent emergence of the photo specialty market, there has been a growing popularity in the printing of photo-related material, such as calendars, photobooks and even stamps, on digital presses. While inkjet printers have benefited from additional inks, digital presses have largely been relegated to traditional 4-color CMYK printing. At last year's NIP conference, we showed that this does not have to be the case with the HP Indigo digital press, which have the option of printing with up to 5, 6, or 7 different colors¹. This paper will focus on the use of light cyan, light magenta and gray inks for creating gallery-quality photography catalogues.

Light Cyan and Light Magenta Advantages

The advantages of light cyan and light magenta in an Indigo press were detailed back in NIP 18². The following magnified scans of actual Indigo print samples highlight the superiority of 6-color CMYKcm printing (figure 1) over traditional 4-color CMYK printing (figure 2) in the areas of smoothness, graininess, detail and lack of artifacts.



Figure 1. Closeup of image printed using traditional 4-color CMYK.



Figure 2. Closeup of image printed using traditional 6-color CMYKcm.

Improved Grey Neutrality

In order to reduce the perception of grain, composite black (overprinting of cyan, magenta and yellow to create black) is often used along the neutral axis, especially for highlight tones, where grain is most perceptible. Because the human eye is extremely sensitive to subtle hue variations along the neutral axis, the task of achieving a perceptually neutral tone throughout the grayscale ramp is especially challenging when using a 4-color CMYK printing system. Even a small fluctuation in one of the channels can result in a print that appears greenish, reddish, too warm, or too cold.

The Photosmart 7960 solved this problem by adding two shades of gray ink and was met with industry-wide praise for its outstanding black and white photo capabilities. In fact, studies showed that consumers preferred the overall quality of the 8-color prints from the 7960 over conventional centralized photo processing as well as competing 6-color printers².

The Indigo digital press can similarly benefit from the addition of a gray ink. As an experiment, Pantone Cool Gray 9C ink was added to an HP Indigo press 5000. To test for gray neutrality, a grayscale target consisting of 33 equally-spaced patches (figure 3) was printed using 2-color K + gray, along with traditional 4-color process CMYK as a reference. Custom ICC profiles were created for both test cases using the same target, measuring device, and profiling software. For the 4-color CMYK separation, a medium GCR setting was used, black ink was introduced at 20%, and a maximum of 400% ink was allowed. The prints were then measured on a spectrophotometer and the data was saved as CIE Lab under D50 illuminant.



Figure 3. 33-path grayscale target used for testing gray neutrality and sensitivity to changes in illumination.

The results are summarized in figure 5. With the 2-color K + gray printing, variations in the a^* axis were reduced by approximately 45% over the 4-color path, while variations in the b^* axis were reduced by approximately 78% (CIE deltaE94 metric).

Improved Illumination Sensitivity

Another important attribute of black and white prints is how the appearance changes under different illuminants, such as daylight (D50), incandescent or fluorescent. This is known as illumination sensitivity, and is measured as a deltaE color inconstancy index under a pair of different illuminants⁴. This an important measure because books, catalogs, albums and printed material are often viewed in various environments with different light sources. It is desirable for the printed piece to have the same visual appearance under these different illuminants.

To evaluate the potential improvement in illumination sensitivity when a gray ink is added, the spectral data from the same 33-patch gray target was used, and the deltaE94 differences between D50 and fluorescent illuminants were computed. Over the 33 gray patches, the 2-color K + gray combination reduced the deltaE94 difference of the 4-color CMYK combination by a mean of 85% and a maximum of 90% (figure 5).

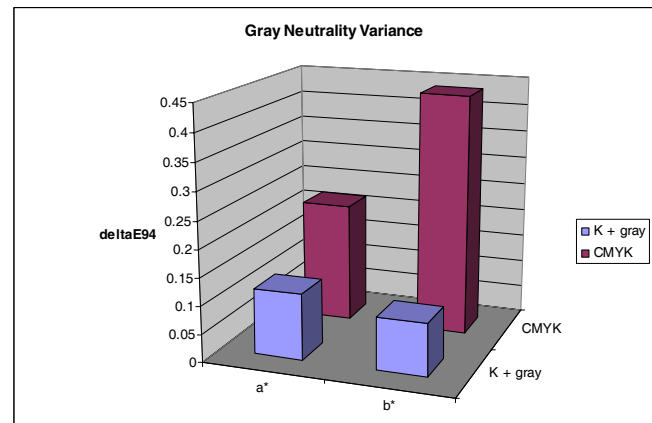
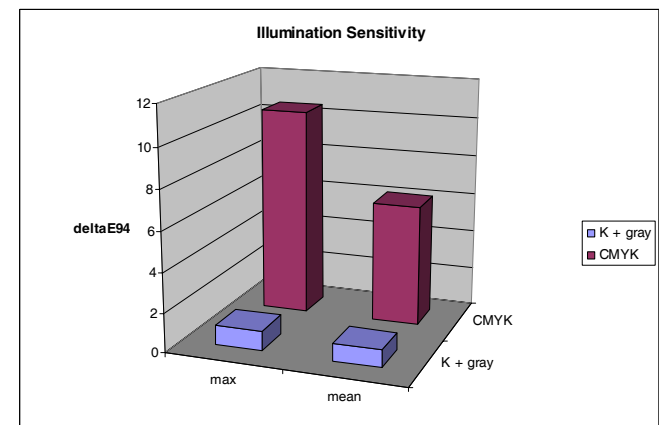


Figure 4. Gray Neutrality Variance comparing 2-color K + gray with



traditional 4-color CMYK

Figure 5. Gray Neutrality Variance comparing 2-color K + gray with traditional 4-color CMYK

The improvement is nothing short of astounding. By using a 2-color K + gray process to print black and white images on an Indigo digital press, the resulting prints will be extremely stable under a wide variety of lighting conditions.

Case Study: Joel Meyerowitz Catalog

In March 2006, award-winning photographer Joel Meyerowitz approached Hewlett-Packard Labs to discuss the idea of producing a high quality catalogue on the HP Indigo digital press for his upcoming exhibit of vintage color photographs, which was scheduled to be held at the Edwynn Houk Gallery in New York from April to June 2006. Meyerowitz is known as a pioneer in the field of color photography and was one of the first photographers to embrace the color medium at a time when serious photographers only used black and white. It was a perfect opportunity to test out the capabilities of the Indigo digital press with a project where color and image quality are of utmost importance. Within two weeks, digital files were being electronically transferred cross country from New York to Palo Alto and printed on the HP Indigo press 5000 on site. Although hardcopy inkjet proofs were sent to HP Labs by Meyerowitz's assistants, the real reference turned out to be calibrated monitors on both ends.

As the design of the catalogue took shape, it quickly became apparent that the gallery catalogue would be an excellent showcase of Indigo quality using light cyan, light magenta and gray inks. Sam Silvio of Silvio Design in Chicago designed the final layout and took advantage of the availability of a gray ink by specifying that color for all the text used throughout. In total, forty-five color images were reproduced in the catalogue with one each on the front and back cover, reproduced in 7-color CMYKc + gray, and the remaining forty-three images reproduced in 6-color CMYKc. Because of the alternating arrangement of pages containing only text and only an image, the interior pages were printed 6-over-1, which represents a 12.5% improvement in productivity when compared to a traditional 4-over-4 printing process.

In April 2006, the first proof of the eighty-eight page catalogue was sent to Meyerowitz, and much to our delight, he was extremely pleased with the output. "To say the printing looks good is an understatement!! Wow! The Indigo is an amazing machine. The overall 'feel' of the work is in the right spirit and shows off the subtlety and color elegantly... the work is astonishingly high quality. I am deeply grateful and truly impressed."

Upon receipt of the final version of the catalogue, Meyerowitz added, "I can't tell you the pleasure I take from the book each time I show it to someone and hear them exclaim over the quality of the printing. It's the printing that gives or takes life to the photographs and this printing certainly is life enhancing!"

Conclusion

Leveraging from their years of experience with inkjet photo printing, HP is once again raising the bar for image quality, this time in the area of digital publishing. With the addition of light cyan, light magenta and gray inks to the Indigo digital press, true gallery quality printing can be achieved.



Figure 6. The cover of "Joel Meyerowitz: Modern Color Vintage Prints", produced on the HP Indigo press 5000 using CMYK + light cyan, light magenta and Pantone Cool Gray 9C.

References

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Author Biography

Kok-Wei Koh earned his B.S. with distinction in Computer Science (*magna cum laude*) from the University of Washington, Seattle, in 1994, and his M.S. in Computer Science from Stanford University in 2002. He has been working in the Digital Printing and Imaging Lab of HP Labs since 2000, where he conducts research experiments on all things color related.

Ehud Chatow received his B.Sc. and M.Sc. degree in Physics from Tel Aviv University and his MBA from Kellogg / TAU. Since 1988 he has worked in Indigo (now part of HP) Israel in several R&D positions among them Project Manager, Ink Department Manager, R&D Materials Section Manager and is now in HP labs.