A NEW TECHNIQUE FOR PRODUCING HIGH FIDELITY COLOR SEPARATIONS

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Abstract: In result of the continuous efforts to improve the quality of printed full color images, new techniques have emerged. Expanded-gamut color printing otherwise known as HiFi (High Fidelity) Color is a term that, for many people, characterizes the future of the printing industry. Images reproduced with HiFi color techniques offer superb color gamut. HiFi color methods were first received with great enthusiasm, but people engaged in research and experiments have also viewed them with criticism because of the problems with their practical applications. In this paper, HiFi color is examined as a whole, and a new technique for producing HiFi color separations is presented. The concept of this technique is to utilize traditional separation techniques in order to produce HiFi color separations according to the MaxCYM method.

Introduction

For the last three years, we have seen an explosion of interest in the four-color process. While it may be the most elite method, the four-color process was never designed as the optimum method of color reproduction. Fine art printers have known this for years and have traditionally printed as many colors as needed to match the original artwork. The four-color process was designed to yield acceptable full-color reproduction using a minimal number of colors (cyan, magenta, yellow, also called substractive primaries, and black). In theory, we can reproduce a very large gamut of colors when combining the substractive primaries and black. However, due to limitations mainly posed by the printing process and the apparent impurities of the inks used, the real gamut is considerably compressed.

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In the contemporary graphic arts industry, one must be able to go a step further in order to distinguish himself and one's products in this colorful world. Color must be evaluated and reproduced differently than ever before. The techniques that can be used to achieve this different type of color reproduction are based on one of the most promising developments for serious color professionals. Technically, it is called expanded gamut or extra-trinary color reproduction, or more commonly HiFi (High Fidelity) Color.

The Imperfections of the Four-Color Process - Gamut Compression

The problem with offset printing is that it produces a relatively narrow color gamut, mostly due to its inability to render high ink densities and strongly saturated colors.

A normal color transparency original contains colors with densities up to 3.3. None of the common printing processes (lithography, flexography) can render colors with densities more than 1.8 (with the exception of gravure which can produce densities up to 2.0). Therefore, a tone compression is required in order to adjust the density range of the original to the requirements of the reproduction. This, in turn, leads to a compression in the color gamut.

In addition, printing inks, in theory, should absorb one third of the visible spectrum, according to the substractive color theory which is the theory that governs the reproduction of images on white paper. Ideally, a cyan ink should reflect all the blue and green light and absorb red; a magenta ink should reflect all blue and red light and absorb green; and a yellow ink should reflect all red and green light and absorb blue.

In reality, the inks used for color reproduction are not ideal and are characterized by unwanted absorbtions. These unwanted absorbtions alter the colors of the final printed image, especially where the substractive primaries are combined. Even with the use of proper color correction, the problem still exists.

Therefore, the four-color process is an approximation of full color. It is the lowest common denominator, using the bare minimum of color set to reproduce the millions of colors the human eye can see. At its very best, it can reproduce only a few thousand of those colors.

The concept that underlies behind most HiFi methods is that using an additional i.e. red ink, instead of combining magenta and yellow, makes it easier to reproduce with greater accuracy and consistency (stability) a red object in an image. Moreover, higher ink densities can be achieved if some magenta and yellow are added to the object which has already been printed with red ink.

HiFi Methods

Currently, there are only three ways to expand the gamut of reproducible color beyond the possibilities of the conventional four-color process:

a. Use of cleaner CMY inks

b. Adding extra RGB inks

c. Adding extra CMY inks

Cleaner CMYK Inks
As mentioned before, conventional printing inks are characterized by unwanted absorptions. The logical solution to reproducing more accurate colors is to use cleaner (reduced unwanted absorbtions) and/or more highly pigmented inks and print on better paper.

Kuppers technique (CMYK+RGB)
In 1980s, a German printer, Harald Kuppers, augmented the substractive CMYK ink set with additive red, green, and blue primaries. Kuppers made his separations through skill-intensive digital retouching and never claimed an automated process, but it was the first example of what is now referred to as the "Kuppers technique".

Kuppers extra inks included a very clean orange-red, a reflex blue, and a clean, saturated green which improved the reproduction of orange-reds, royal blues and bright greens. He also recommended a somewhat greenish cyan which limited the gamut of cyan-blues and is typically replaced by a more conventional cyan ink.

The adoption of the Kuppers' Technique was limited, firstly, because of the use of seven plates which required special screening to avoid moire, and secondly due to the high cost (few jobs justify printing with seven plates, and the extra units of seven- or eight-color presses are often used up by a special color plus a varnish, leaving at best five or six units for the process work). The first problem was partly resolved by placing the CMY inks on one angle, the secondary inks (RGB) on a second angle, and the black on a third. However, by using 100% GCR it is possible that cyan, magenta and yellow can be prevented from ever printing together by substituting two of the three substractive primaries with a certain amount of black. In this way, if it is necessary, every color can be reproduced by combining a certain amount of a substractive primary with a certain amount of black. Another example of preventing moire problems is the algorithm used in Hexachrome, where magenta can be prevented from ever printing with green by using cyan and yellow wherever magenta is printed with green. Similarily, orange can be prevented from printing with cyan by using magenta and yellow wherever cyan is printed with orange. In this way, magenta and cyan can share the same angles with green and orange, respectively.

MaxCYM (CMYK+CMY)
This approach has been characterized as "the path of least resistance to Hi-Fi". The idea is to use a second set of CMY plates to maximize the density of regular inks. The first four plates look almost like a conventional four color set but the second three carry detail only where the image needs more than 100% of each ink. Laying down twice a cyan, magenta, or yellow ink can achieve color densities up to 2.2 or more with corresponding dot sizes up to 200%.

The most significant advantage of MaxCYM is that it maximizes the ink densities while remaining compatible with standard SWOP inks. In other words, it does not require any special inks other than the ones used for the conventional 4-color process.

In addition, when using conventional screening, moire is not a problem because the second plate of each color prints only where the first plate is solid (100%). As a result, only four screen angles are needed. Frequency modulated screening is not required, but it can be used as it is the case with any conventional four color printing reproduction.

Hexachrome™

This is the most recent HiFi implementation which was developed by Pantone. The idea behind Hexachrome was derived from both the Kuppers' and cleaner CMY inks methods. Specifically, it uses six colors (a highly pigmented cyan; a clean, highly pigmented semi-fluorescent magenta; a bright orange; a clean green; and fairly conventional yellow and black inks.

Hexachrome™ can render more than 90% of solid PMS colors, compared to the 50% achievable with traditional CMYK printing.

A new technique for producing HiFi color separations according to the MaxCYM method

The objective of this technique, devised by the author, is to produce HiFi color separations utilizing conventional separation techniques, by applying the concept of MaxCYM.

An experiment was conducted in order to evaluate the validity of this technique. A color transparency was scanned with a Crosfield scanner (the corresponding grayscale image of the tranparency is shown in Fig. 1). The separations produced were proofed with the Fuji ColorArt proofing system and the result was compared with a proof of the same image made with conventional four color separations made by the same scanner and under the same conditions.

Experimental Methodology

The concept of this technique is to make two scans of the same image but with different settings on the highlight, midtone and shadow points.

A transparency copy was mounted on the scanner according to the offset mounting technique. The density range of the original was determined to be 2.5 (highlight at 0.3 density and shadow at 2.8 density). In all cases, a step tablet was used for setting the highlight,midtone, and shadow point, in order to keep the color cast of the original.

In the first part of the HiFi scan, the shadow point was placed at a density of 2.2, the midtone at 0.9, and the highlight at 0.3. The result of this is the production of four separations (CMYK) which correspond to the first set of inks (CMYK) in the MaxCYM method. In these separations, the areas that correspond to areas on the original with densities larger than 2.2, will have 100% dots. In simple words, if only these separations were used in for reproducing the original, the areas mentioned above would be solids.

Fig. 1 The image used for producing the separations

In the second part of the scan, the highlight point was placed at a 2.2 density, the midtone at 2.4 and the shadow at 2.8. The second scan will produce the separations that correspond to the second set of inks (CMY) in the MaxCYM method. Since we need only Cyan, Magenta and Yellow separations (not Black) the scanner was set to produce three separations only. The result of the second scan was the creation of separations where the areas that correspond to areas on the original with densities lower than 2.2 will have no halftone dots at all (0% dots).

By applying the second set of inks (that correspond to the second set of separations (CMY)) over the first one, the areas which were reproduced as solids with the first set of inks, would now have a differentiation in densities. This is the concept of MaxCYM. The density 2.2 that is used as a shadow point for the first scan and as a highlight point for the second scan is called MaxCYM Midtone Density (MMD).

In addition to the first HiFi scan, a second HiFi scan was made, with a MaxCYM Midtone Density (MMD) of 1.9 in order to compare the result of placing the MMD at different densities. The midtone point in the fist and second part of this scan was placed at 0.9 and 2.1 densities, respectively. Fig. 2 depicts an approximation of the Tone Reproduction curve used in the above scans.

Producing HiFi color separations is difficult; proofing them is even more difficult. However, MaxCYM separations are easier to proof since no additional inks of different colors are required.

In this experiment we used the Fuji Color Art proofing system, which is a transfer proofing system. The main problem of this proofing system is the excessive Yule-Nielsen effect which results from the heavy film base. In addition, the overlap colors are often different with the press results, because ink trapping cannot be adequately simulated.

Based on the Fuji proofs, the normal scan proof with the two HiFi color proofs were compared.

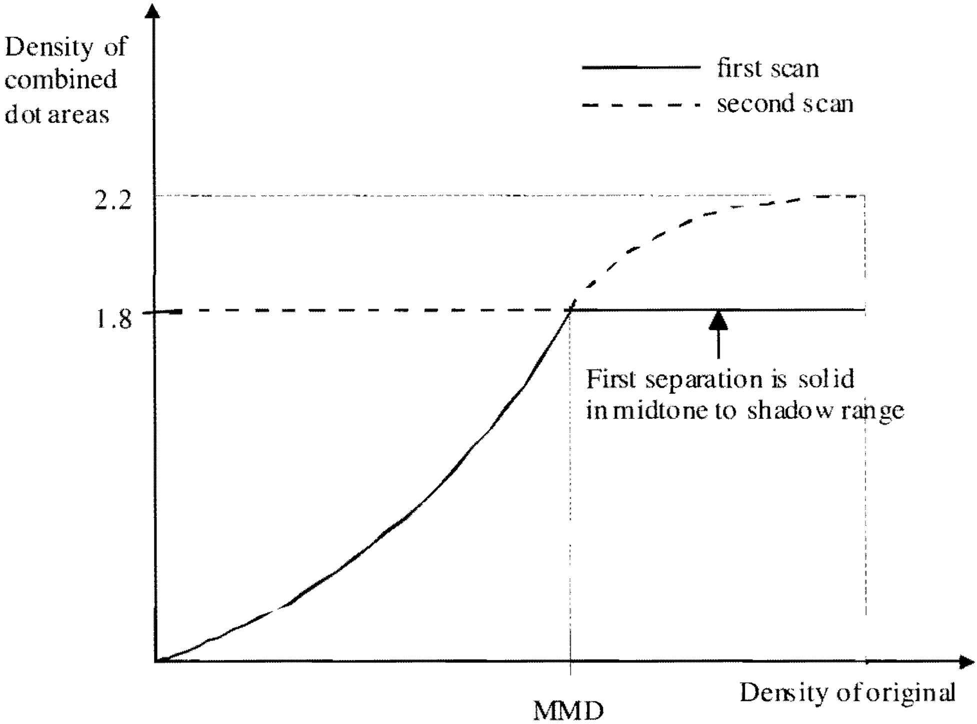

Fig. 2 An approximation of the Tone Reproduction curve for the HiFi scan

Evaluating the proofs
The first obvious observation is that both HiFi color proofs have much more saturated colors, especially reds and blues, and considerably higher contrast. The color of wood (the color of the musical instrument) was extremely well reproduced, especially in the HiFi proof with an MMT of 1.9. The latter proof, although it had more saturated colors than all other proofs, it appeared to have a loss (small though) in shadow detail. Both HiFi proofs appeared to have a small loss detail in the shadows which should be attributed to the inherent excessive optical gain.

In the HiFi proof with MMD of 1.9, the midtone point (in the first part of the scan) was placed at a 0.9 density, which means that the tone reproduction curve will be almost a straight line (in the case of printing with lithography) since the maximum density that a lithograpic press can achieve (on coated paper) is 1.8. This in turn means that all densities up to 1.9 (highlight to midtone range of the original) are accurately reproduced (choosing a MMD of less than 1.8 would not produce good results since this would result in an inaccurate reproduction of the highlight to midtone range-excessive contrast). The densities above 1.9 and up to 2.8 are reproduced by the second set of separations, which increases the highest density on the press sheet to around 2.2 (that's the highest density that all seven colors can achieve). This means that the tone compression takes place between 1.9 (MMD density) and 2.8, that is in midtone to shadow range of the original.

By increasing the MMD density less colors in the original are going to affected by the second set of separations. However, if we keep a low MMD (i.e. 1.8) more ink will have to be trapped above the first set of colors, on the press, which means that we should choose a higher density to reduce ink trapping problems. A MMD density between 2.0 and 2.2 should offer good results.

Scanning Specifications

System:
Crosfield Magnascan Plus scanner connected to a PowerMac 8100/80.

Specs:
Copy: 2 1/4 in. transparency AntiNewton Ring Mounting Technique: Offset
Screen Ruling: 150 lpi Reproduction size: 200%

All of the below densities refer to step tablet densities (color cast was kept)

Screen angles:
CMYK: 105, 75, 90, 45
CMY: 105, 75, 90

Scan 1: Normal Scan

Highlight	B .28	G .27	R .27
Shadow	B 2.8	G 2.8	R 2.8

Scan 2a: CMYK

Highlight	B .28	G .27	R .27
Shadow	B 1.9	G 1.9	R 1.9

Scan 2b: CMY

Highlight	B 1.84	G 1.85	R 1.88
Shadow	B 2.8	G 2.9	R 2.9

Scan 3a: CMYK

Highlight	B .28	G .27	R .27
Shadow	B 2.2	G 2.2	R 2.2

Scan 3b: CMY

Highlight	B 2.2	G 2.2	R 2.2
Shadow	B 2.8	G 2.9	R 2.9

Proofing Order:
K C M Y C M Y

Conclusions

The technique described above for producing MaxCYM separations offered very good results, producing more saturated colors and increased contrast which is due to the higher maximum densities that can be achieved by the seven layers of colors (2.2 instead of 1.8).

In general, when considering reproducing an image using one of the HiFi methods (MaxCYM, Kuppers', HexachromeTM) it should be noted that each of these methods is best suited for images that carry a specific combination of colors. For instance, MaxCYM is well suited for fashion, travel, automobile, and food images because of the saturated reds, greens, blues, and cyans it creates. Kuppers' and Hexachrome techniques are more HiFi color oriented, in terms of greatly expanding the achievable color gamut. Experiments have shown that the color gamut expands remarkably with additional orange, violet, and blue.

Marketing HiFi color is an important issue that makes most printers hesitate to adopt HiFi color technology. The majority of four-color printing does not need the additional lift, considering its high cost. Nevertheless, there are going to be jobs, particularly metallic colors or those that are difficult to reproduce from CMYK, where the client would be prepared to pay for the additional work involved.

Concluding, one can think of HiFi color as the only means for conventional printing industry to compete with the possible future effect of CD-ROM or short-run electronic publishing, by providing superb color quality and printed images that many people would claim they look better than their original.

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