

Effect of Gray Component Replacement on Color Reproduction

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Abstract

Gray Component Replacement is a separation technique for replacing cyan, magenta and yellow inks with black throughout the image. In this separation, black inks reduce the amount of process colored inks which are expensive. It offers more consistent color and gray balance. Total ink coverage (TIC) is reduced to a great extent by GCR. More critical colors like flesh tones can be better adjusted by this separation. Brighter colors can be obtained on lower grade papers. However, Gray Component Replacement is not always the best choice. Sometimes, it reduces the ability to adjust colors. It may create problems with balancing black halftone. High amount of GCR causes the shadow areas to print too weakly resulting in low contrast. To alleviate the lower Total Coverage with high level of GCR, undercolor addition (UCA) is often required in the achromatic areas of the image. In the present work, the investigators have taken different prints in a HP Deskjet printer varying the amount of GCR. The prints are then compared with the originals. The total ink coverage (TIC) is measured for each image in different areas of grays ranging from highlight to shadow. The tone reproduction curves are drawn to observe how GCR affects image quality and total ink coverage of color reproduction.

Introduction

Gray Component Replacement (GCR)is the separation technique to replace cyan, magenta and yellow wherever they overprint to produce neutral gray. This process is also known as achromatic color separation . Undercolor removal

(UCR) is the separation process where equal amount of the process color inks are replaced by black ink in the neutral gray areas in the shadow region. In 1980s, the electronic color manufacturers began achromatic color reduction in their devices.

GCR and UCR are incorporated into an image to achieve various degrees of detail, color control and to reduce ink density and usage. In ideal situation, equal dot areas of cyan, magenta and yellow inks would produce equivalent amount of gray and thus black separation would offer the same visual gray tone with less color ink and thus less total ink. However, in practice, the amount of cyan, magenta and yellow needed to reproduce gray tone are slightly unequal due to deviation from ideal behavior of ink and paper.

The major advantage of GCR is consistent color reproduction throughout a pressrun. Since greater amount of black ink is used ,better gray balance is being maintained It is easier to control more difficult colors like flesh tones and wood tones .The total ink coverage (TIC) is much less in GCR. This enables to use lighter weight papers. Brighter colors can be obtained even in low grade papers. The trapping problem is also less. It offers less dot gain with higher print contrast. The drying problem is reduced with faster printing speeds. Normally, the printing is sharper since the details are present in the black halftone. However, undercolor addition is sometimes essential to obtain proper color adjustment and to avoid misregister.

Experiment

A Macintosh LC475 with UMAX VISTA T630 scanner is used for color separation with Adobe Photoshop. Different photographs are taken for color separation ranging from low key to high key images.

The system is properly calibrated first to obtain good color separation. The scanning is done at 400 dpi resolution with proper calibration and setting in RGB mode. The color separation is conversion of RGB image to CMYK image.

The settings in the Separation Setup dialog box controls how the mode conversion is done. The program converts the RGB mode to CMYK mode using information in the Monitor Setup, Printing Inks Setup and Separation Setup dialog boxes to achieve best possible final output.

The Separation Setup dialog box shows a graph how neutral colors in the image will separate with the help of gray ramp. The x-axis in the gray ramp represents the neutral color value while the y-axis represents the amount of each process color ink which will be generated for the given value.

The separation settings offer the method used for black generation by UCR or GCR and total ink limit. The separation setup is adjusted by selecting UCR or GCR for a particular image. Different options are available for GCR separation for choosing the degree of black generation, setting black ink limit, total ink limit and indicating undercolor addition.

For each image, the black generation is done by varying the options like Light, Medium, Heavy or Maximum and the images are printed in a Deskjet printer .The corresponding gray ramp settings are also printed for each separation and compared. The total ink coverage is measured for each images in different areas of grays ranging from highlight to shadow. The black ink limit is adjusted form 40% to 100% to observe the effects of it in the image quality. Tone reproduction curves are then plotted to observe how the degree of black generation and black ink limit affects image quality and total ink coverage.

Results and Discussion

The histograms of the images show how the pixels of the images are distributed. An image whose detail is concentrated in the shadows is low-key image. An image whose detail is concentrated in the highlights is high-key image. An image whose detail is uniformly distributed from highlight to shadow is known as average key image. In this work, different images from low key to high key have been selected. The total ink coverage for low key, average key and high key images with different degrees of black generation are plotted in Figure 1, 2 and 3 respectively. It has been seen that the separation effects are different for different key images.

Theoretically, printing of 100% of cyan, magenta, yellow and black may result in 400% total ink coverage. But in practice, it is difficult to print when TIC exceeds 300% and most printers prefer with a maximum 260% coverage. Since maximum allowable ink coverage is a function of print speed and ink tack, it is essential to keep ink coverage to a minimum to prevent back transfer.

In case of Undercolor Removal, the black ink is used to replace process color inks and thus provides better economy since process inks are more expensive. However, it has been seen from the experiment that the total ink coverage is not reduced in an appreciable amount by UCR. This may be due to the fact that black ink is used not only to create solid black, but also to add detail and deepen shadow areas. Moreover, the maximum density of the printed sheets decrease which results in lower contrast and quality.

Figure 1 shows the effect of GCR on TIC for low key image. It has been seen from the figure that for low key objects, TIC in highlight areas are more or less same for different levels of GCR. When light options are taken for GCR, reduction in TIC is not appreciable. However, the image quality is good enough. For medium separation, TIC is reduced to 5-10%. When heavy option is taken for GCR, about 20% reduction in TIC occurs. For maximum GCR, TIC is reduced to 30% in midtones to 40% and above for shadow areas. But the neutral grays appear grainier than the rest of the image since process color inks are almost absent in those areas.

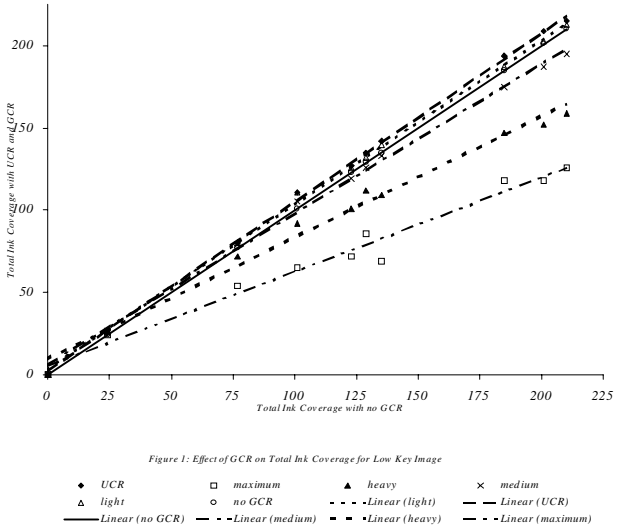

Figure 1: Effect of GCR on Total Ink Coverage for Low Key Image

UCR, maximum, heavy, medium, light, no GCR, Linear (light), Linear (UCR), Linear (no GCR), Linear (medium), Linear (heavy), Linear (maximum)

Figure 1.

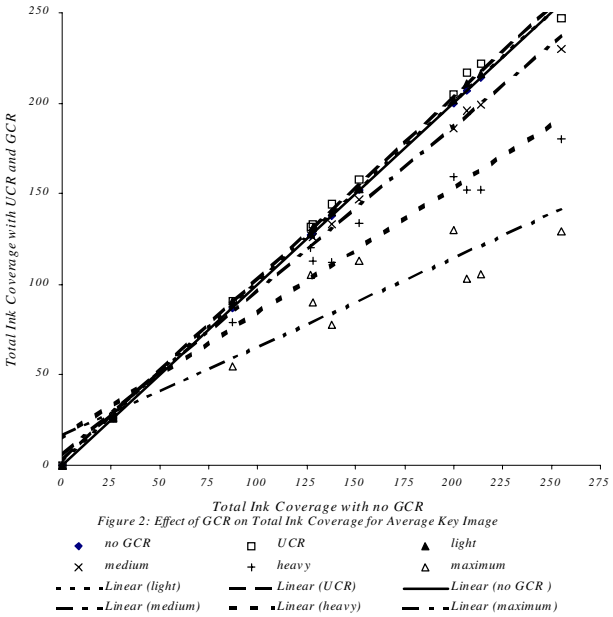

Figure 2: Effect of GCR on Total Ink Coverage for Average Key Image

no GCR, UCR, light, medium, heavy, maximum, Linear (light), Linear (UCR), Linear (no GCR), Linear (medium), Linear (heavy), Linear (maximum)

Figure 2.

Figure 2 shows the effect of GCR on TIC for average key image. From the curves, it appears that the highlights as well as lower midtones remains almost unchanged by GCR. The TIC is almost unchanged for light GCR. However, the image quality is much better for light GCR option. For medium option, the reduction is more or less

similar as in the case of low key images and restricted to 5-10%. However, for heavy GCR, more reduction in TIC occurs for average key images than low key images and it allows about 30% reduction in TIC in shadow areas.

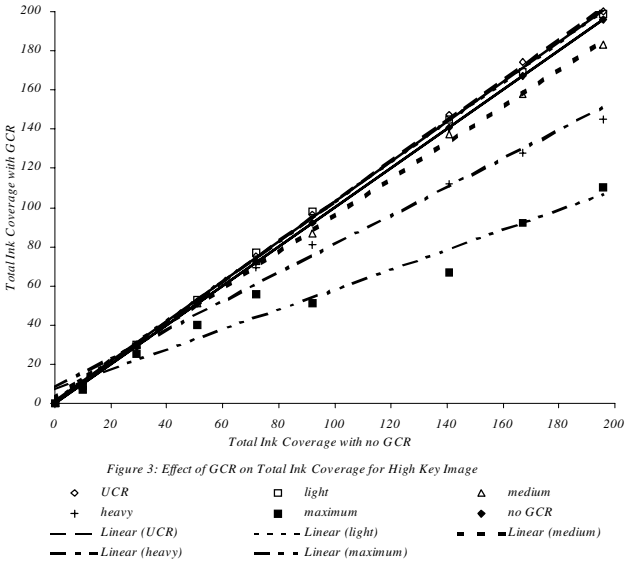

Figure 3: Effect of GCR on Total Ink Coverage for High Key Image

Figure 3.

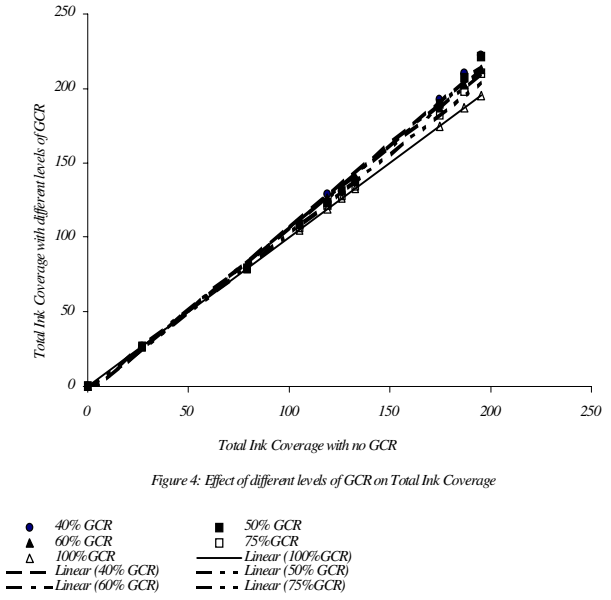

Figure 4: Effect of different levels of GCR on Total Ink Coverage

Figure 4.

For maximum GCR, TIC reduction ranges from 30% in midtones to about 45% in shadows. The quality of the image is not good enough for maximum GCR. It has been seen for the image that the tone reproduction curves are linear when the degree of separation is light or medium. However, the correlation coefficient gradually reduces to 0.79 indicating higher degree of polynomial equation and thus variation of TIC from highlight to shadow.

The effect of GCR on TIC for high key image is seen in Figure 3. In highlight and lower midtones, the reduction in TIC is negligible for all GCR .The reduction in TIC for medium, heavy and maximum is similar to average key image. The high key image shows more appreciable variation in the density of the black channel in comparison to low key image when the level of GCR is increased from light to heavy option.

The curves showing how TIC is affected by varying black ink limit with medium black generation are plotted in Figure 4. It has been observed that the total ink coverage is not reduced significantly as the black ink limit reduces. However, the image quality is better with less amount of black ink. When 100% GCR is applied, process ink values in shadow area becomes 0% . This will cause the shadow area to print too weakly and to loose contrast. Hence, when applying GCR, the softwares often limit the reduction of CMY in the shadow area to 200-225% TIC. However, it is essential to check the TIC in the shadow areas of the image after applying GCR and if necessary, undercolor addition is to be done.

Conclusion

The theory behind Gray Component Replacement is replacement of cyan, magenta and yellow inks by black ink wherever they overprint. The separation is called achromatic because gray component is replaced by black. GCR increases the amount of black ink with a proportionate decrease in process color inks. Economy is good reason for using GCR which reduces consumption of expensive colored inks and less paper wastage. In this work, it has been observed how Total Ink Coverage is reduced with increasing GCR. This offers less wastage because of thinner film. Finally, lighter paper can be used. However, the choice is not always the best one. Proper tone reproduction and color correction for black separation is critical while applying GCR because the black is also used to reproduce dense black in shadow region. Though TIC is reduced with increasing GCR, the shadow areas print too weakly for all types of images and the overall appearance of the reproduction looses contrast. Hence an optimization is necessary between image quality and cost. For better reproduction, light or medium GCR is good enough for Low Key image. For Average or High Key image, GCR is preferred to avoid overinking of process color inks.

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Biography

Swati Bandyopadhyay received her Bachelors degree in Chemical Engineering from Jadavpur University , India in 1987. She has obtained Ph. D. (Engg.) in 1995 from the same University. She is working as a Faculty Member (Reader) in Printing Engineering Department of Jadavpur University. She has teaching experience of about nine years. Her research areas are Image Quality of Color Reproduction and Ink-jet ink properties.