Translation of the Infrared into a Visible Area with Double Separation

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Abstract. *Information visualization refers to the wavelength area ranging from 400 to 700 nm. Contiguous areas in lower wavelengths ranging from 100 to 400 nm are translated into the visual area with the goal to protect information visible only by applying instruments adapted for the ultraviolet area. Our recent research work refers to the infrared wavelength areas above the visible specter up to 1000 nm. An algorithm has been created for making visual basics in the overall visible specter containing material that responds in the infrared section.*

This allows planning of areas in all coloring types for one and the same document that contains a secure piece of information. The system is based on double transition transformation of the visible RGB[1] information recognition into CMYK[2] using GCR[3] and UCA[4] method in the same document.

Secure information is recognized with the help of instruments in the set wavelength range. Most of the experiments have been made by analyzing the same set of RGB records. Each sample in the set was a test unit from another source containing different IR[5] components. The procedures for finding counterfeits have been set thereby, the document's life estimate and the original's physical state. Hidden information is revealed, lost and destroyed by some of the conventional methods.

Keywords. Security Graphics, Infrared Colours, Colour Separation

1 Introduction

Information coming through printed media has been brought to reproduction perfection with the help of digital techniques. A large number of patents are aimed at reaching the authenticity of the print in respect to the original. Methods GCR, UCA and UCR[6] have been developed that break down the information from the RGB visual system into the CMYK system on the level of each image element. The pixel is interpreted as a square or rhomboid graphics. Measurements, experiments and scientific approach to ink separation for the printing process are focused on the final goal, and it is to save ink consumption and to have the best reproduction quality [1]. It is understandable that the extensive literature on inks with their application in printing covers the area of wavelengths from 400 to 700 nm.

Such research work and patents were indispensable in implementing a high degree of automation and safety in carrying out workflows linked with complex graphics production. Now there is extension of research in the infrared area where the reproduction quality is not important but it is important to uncover hidden information for different goals, and the most important area is the one linked with security documents. GCR and UCA methods [2] at the borders of the task of ink separation for printing become the subject of research work in wavelengths above the area visible to the human eye. UCA is applied to pixels we do not wish to view under infrared light and GCR will be applied to those parts of images that are visible in the said area, and where they can be measured precisely. In order to make way for the two methods and their application in security printing, we have disregarded their advantages in

1 Red, Green, Blue
2 Cyan, Magenta, Yellow, Black
3 Grey Component Replacement
4 Under Color Addition
5 Infrared
6 Under Color Removal

respect to low ink consumption, acquiring contrast and improvement in reproduction authenticity. The task linked with document security with process inks in the infrared area has given results about which there has not been any written matter yet. If there had been any knowledge on the matter, it had been the privilege of state printing works for printing securities [3].

2 The principle of double separation of RGB transition into CMY

Theoretical settings begin with simple relations:

C+R=1
M+G=1
Y+B=1

A black component is introduced with two extremes [4]. The first one is when the K component defined as the value of minimal coloring in one of the C, M, Y components is maximized with the GCR method. Such GCR method application implies that one of the process inks disappears:

K= min(C, Y, K)

On basis of this, final values are derived:

C=1-R-K
M=1-G-K
Y=1-B-K

The second extreme is the minimal K where process colors are controlled with the help of the UCA and UCR methods:

K=0
C =1-R
M =1-G
Y =1-B

In each real-life printing combinations colorings do behave differently. For final reproduction it is important that the system for absorbing and reflecting light behaves well for RGB receptors in our eye. This depends on the material from which the ink is made, on the paper it is printed on, the printing technique.

Report in this work is based on experiance grayness but printed with colors cyan, magenta and yellow. Maintenance of the RGB system and separation for digital toner printing has given based on the measurement the following relations for 40% black coverage:

$C = 40 - 0.01152*K^2 - 0.3618*K$
$M = 40 -0.00485*K^2 - 0.3362*K$
$Y = 40 - 0.00485*K^2 - 0.4327*K$

where in the whole area we see the grayness $C_0 = M_0 = Y_0 = 40$. This is shown in graph (Fig. 1). Lines C_1, M_1 and Y_1 are illustrations of linear settings:

$C_1 = 40 - 0.888*K$
$M_1 = 40 - 0.6*K$
$Y_1 = 40 - 0.644*K$

if we permit the tolerance in the equalization of gray experience. The graph beginning corresponds with UCA separation with minimal black component values.
General ralations for gray in span from 5% to 90% of blak coverage is suggested as:

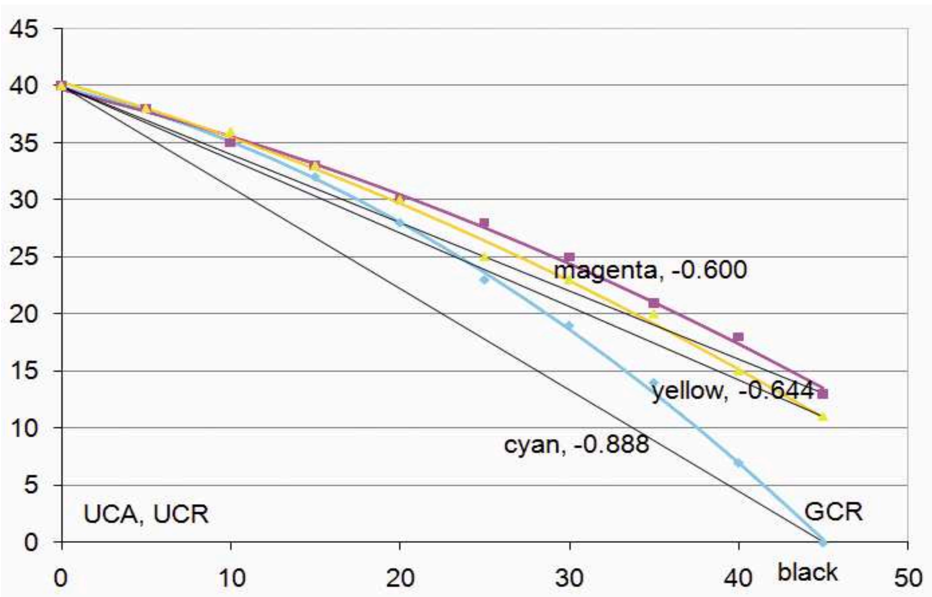

Figure 1. separation for digital toner printing for 40% black coverage

$C=C_0 - (K_2 * S_c)$
$M=M_0 - (K_2 * S_m)$
$Y=Y_0 - (K_2 * S_y)$

where $K_2 = \min(C_0, Y_0, K_0)$ and where

$S_c= a_cC_0+b_cM_0 +c_cY_0 +d_c$
$S_m= a_mC_0+b_mM_0 +c_mY_0 +d_m$
$S_y= a_yC_0+byM_0 +c_yY_0 +d_y$

Parameters, a, b, c and d are the results of measuring and determined on basis of linear regression analysis with values in Table 1.

Table 1

	a (at cijan)	b(at magenta)	c (at yallow)	d
Sc	0,016422	-0,0149	-0,00161	0,8379
Sm	-0,01132	0,00905	0,00453	0,500
Sv	-0,00518	-0,00955	0,01856	0,488

The relations is for the all values of K (black) from zero up to maximum. The values in Table 1. is only for start color (K=0) with equalization $C_0 = M_0 = Y_0$. The maximum K is a GCR procedure. Equations are necessary in order to incorporate them into our program of double separation. In such a way continuous joining of the black color is made possible as a basis for obtaining the IR effect. Double separation means there is continuous separation depending on some external parameter.

3 The mask, or external separation control parameter

The infrared area is known in printing business literature as the IR black visible and IR black invisible. In printing practice this is achieved by mixing two spot black inks: black visible and black invisible under IR light. This practice has no connection with process inks or with conventional transition separation of RGB into the CMYK coloring system.

The given equations are the results of obtaining continuous transition from the invisible into the visible black color under IR radiation with pure process inks. This paper sets forth that process inks are sufficient for covering all IR effects. It is proposed to abandon spot inks for IR security because they can be faked with conventional process inks. What is necessary in this system is the introduction of double separation and separation with continuous control of UCR in respect to the GCR procedure.

Such a system that is treating different separation methods in the same document is set with the help of new software tools. Two images are input ones. The first one is the one that must remain the same in the RGB system of our eye in daylight throughout its whole area. The second input image is a “mask” that controls the separation. Separate are the areas that will be viewed under IR light from the ones invisible under this light. The final separation is the image that is to our eye identical with the first image. There are no disturbances due to various presences of individual pixel separations in relation to GCR, UCR and UCA procedures.

4 Experiment results

Process colors react differently in the IR area. Offset inks, inkjet colors, digital printing toners have their own visibility characteristics in the transition to IR area. We use the experimentally determined visibility characteristics for some process toners for software mixing with the goal being to have some parts of the image be visible and some parts of the image to be invisible under IR radiation. CMYK separation depends on the following wish: what we want to be seen in the IR area and what we do not wish to be

Figure 2 Daylight, mask and IR view

seen in the IR area. Our transformation algorithm of RGB towards CMYK is applied to each pixel.

A mask is placed on a image by which the image is separated into visible and invisible areas under IR radiation (Fig. 2, Fig. 3, Fig. 4, Fig. 5).

Figure 3 Daylight, mask and IR view

The black part of the graphics controls visibility of the basic image in the IR area. The white part of the graphics provides for the image's invisibility in the IR area.

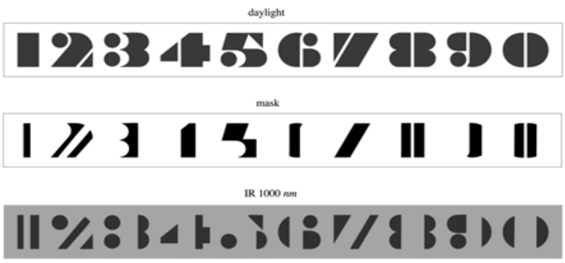

Figure 4 Daylight, mask and IR view

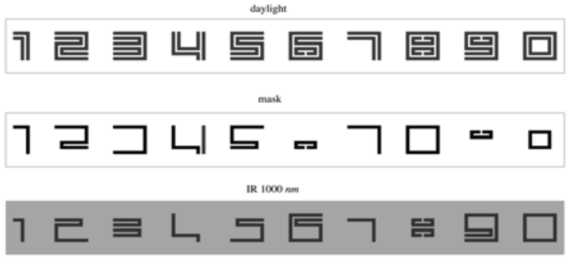

Figure 5 Daylight, mask and IR view

5 Conclusion

The double and continuous separation system is introduced into graphic prepress with the goal to maximize the IR effect. The area of research is being prepared for a new manner of evaluating designs for the infrared light generated by mixing process inks. It is suggested to abandon strict use of spot IR inks. A continuous IR system for all coloring tones is a much better way of protection because it is impossible to locate and set the numerical values with the help of conventional instruments. Therefore, the method of separating RGB values into CMYK values with incorporated continuous changes of visible and invisible coloring under IR light has improved security printing in a most significant way.

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