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Preliminary Communication Article

Double Separation Method for Translation of the Infrared Information into a Visible Area

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Abstract

Information visualization refers to the wavelength area ranging from 400 to 700 nm. 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. The scientific contribution of this paper is in setting the double separation method for printing with CMYK printing inks with the goal to detect graphic information in the infrared area only. 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] in the same document. Secure information is recognized with the help of instruments in the set wavelength range. Most of the experiments have been carried out by analyzing the same set of RGB records. Each sample in the set was a test unit coming from another source containing different IR[3] components. Thus an innovative method of color mixing has been set where colors appear respectively in daylight and separately according to IR light programming. New IR cryptography is proposed as shown in the experimental work.

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[4], UCA[5] and UCR[6] have been developed to separate the information from the RGB visual system into the CMYK

[1] Red, Green, Blue

[2] Cyan, Magenta, Yellow, Black

[3] Infrared

[4] Grey Component Replacement

[5] Under Color Addition

[6] Under Color Removal

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], [2]. 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. The task to find special ink separation for printing in wavelengths above the area visible to the human eye became the subject of research work. One method is applied to pixels we do not wish to view under infrared light and another method is applied to those parts of images that are visible in the said area, and where they can be measured precisely. With this goal in mind original procedures for regression analysis parameter setting have been developed with the help of which relations are obtained for the value translation procedure in respect to the individual pixel coloring of the image for IR protection.

In order to make way for the two methods and their application in security printing, we have disregarded their advantages in 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 method of RGB transition into CMY

Our new approach to security graphics uses specific characteristics that come out from prints individuality, color mixing programming, multi-layer application of colors and controlled ink separation [4]. The input record of one image pixel is marked with the R, G, B threesome, the values of which are inside the interval [0,1]. The value 1.0 represents the highest lightness level and the value 0 represents the lowest one. The complementary RGB and CMY relationships are defined by equations:

$$\begin{aligned} C+R&=1 \\ M+G&=1 \\ Y+B&=1 \end{aligned} \qquad (1)$$

A black component is introduced with two extremes. The first one is when the black component (K) is defined as the minimal value of the C, M, Y components. In this way black is equal with the gray component of the multi-color ink:

$$K= \min(C, Y, K) \qquad (2)$$

Such method implies that one of the process inks disappears. On basis of this, final values are derived:

$$\begin{aligned} C&=1-R-K \\ M&=1-G-K \\ Y&=1-B-K \end{aligned} \qquad (3)$$

The second extreme is when K equals zero where process colors are only complements of primary colors.

$$K=0$$
$$C=1-R$$
$$M=1-G \qquad (4)$$
$$Y=1-B$$

In each real-life printing combination 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 produced from, on the paper it is printed on and the printing technique.

Results in this work are based on experience grayness but printed with tints cyan, magenta and yellow. Maintenance of the RGB system and separation for digital toner printing has been given based on the measurement of the following relations for 40% grayness:

$$C = 40 - 0.01152*K^2 - 0.3618*K$$
$$M = 40 -0.00485*K^2 - 0.3362*K \qquad (5)$$
$$Y = 40 - 0.00485*K^2 - 0.4327*K$$

where in the whole area we see the grayness $C_0 = M_0 = Y_0 = 40$. This is shown in graph (Fig. 1). As there may be rise or decline of output components C, M and Y, in respect to complementary input values, we determine that they have undergone UCA or UCR changes, whereas the black component in the algorithm underwent GCR changes.

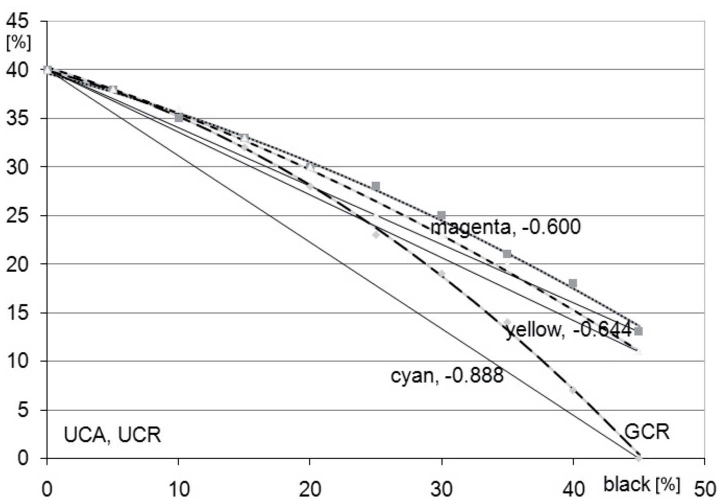

Figure 1. Separation for digital toner printing for 40% grayness

Experimental curves and their approximations have been marked in the graph. With approximating lines marked cyan, magenta and yellow we get linear equations if we permit the tolerance in the equalization of gray experience:

$$C_1 = 40 - 0.888*K$$
$$M_1 = 40 - 0.6*K \qquad (6)$$
$$Y_1 = 40 - 0.644*K$$

The graph beginning corresponds with separation with minimal black component values. General relations for gray in a range from 5% to 90% are suggested as:

$$C=C_0 - (K_2 * S_c)$$
$$M=M_0 - (K_2 * S_m) \qquad (7)$$
$$Y=Y_0 - (K_2 * S_y)$$

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

$$S_c= a_cC_0+b_cM_0 +c_cY_0 +d_c$$
$$S_m= a_mC_0+b_mM_0 +c_mY_0 +d_m$$
$$S_y= a_yC_0+b_yM_0 +c_yY_0 +d_y$$

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

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

Table 1. Results of linear regression analysis: parameters a, b, c and d

The relations are for all values of K (black); from zero up to maximum. Values in Table 1 are 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 infrared effect [5]. Double separation means there is continuous separation depending on some external parameter.

3. The mask or external separation control parameter

The infrared (IR) 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 color 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 method 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 that have been developed by the author for experimental development [6]. 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.

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 the IR area [7]. 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 goal:

what we want to be seen in the IR area and what we do not wish to be seen in the IR area. Our transformation algorithm of RGB towards CMYK is applied to each pixel.

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

Figure 2. Daylight, mask and IR view

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.

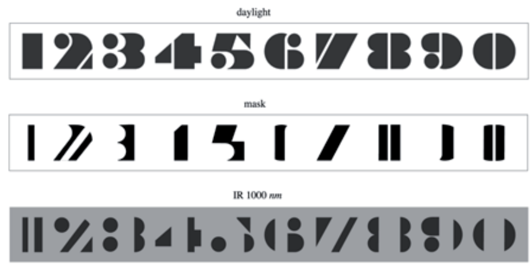

Figure 4. Daylight, mask and IR view

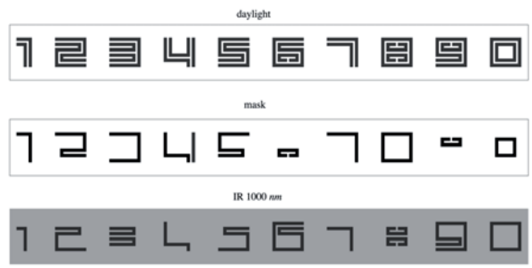

Figure 5. Daylight, mask and IR view

All the experiment examples use relations (Eq. 7) controlling the gray range 5% to 90%. In all examples the IR view is shown at 1000 nm.

In the first example (Fig. 2) the mask was used in the algorithm as the positive for the IR effect. This means that in areas where the mask is positioned, such information will be visible under IR only. Here the mask represents a rectangular barrier only, i.e. a filter for the required information. In the second example (Fig. 3), the mask represents the word "PARKIRANJE" (parking). Under IR light visible are only those original image pixels that are masked with the set mask. The intensity does not equal to the grayness that we observe in daylight, but the required IR intensity obtained with the help of set relations (Eq. 7), whereas the initial condition is maintained that the IR effect is fully hidden when observed in daylight.

In the third and fourth examples the masks are used as negatives for the IR area. For these examples a separate typography has been developed with the aim to introduce cryptographic IR operation. It is here that we introduce the idea of IR cryptography that may be designed as positive and negative masking.

5. Conclusion

The new double separation method 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. With this goal in mind our own solutions have been developed for mixing colors responding under wavelengths from 700 to 1000 nm. With this new scientific method the area for printing security is expanded into the infrared area in a brand new way as to the manner of production, designing and perception of the security effect. The possibility of IR cryptography has been proposed determined by a specially designed font and the accessory IR masks. Further scientific research is linked with other printing techniques and other materials, as for instance: textile fabrics, silk, ceramics and glass.

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