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Hidden infrared image in a uniform CMYK separation hue

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Abstract:
Extended colour management is introduced for integrating the colorants visual characteristics in the visual, but also in the near infrared spectrum (NIR). Many conventional graphic inks are such that their light absorption in the visual (V) and NIR specter can be very well measured, and we are using this for our goal which is the following: firstly to create a double condition of graphic reproduction - invisible graphics to the human eye, but allowing to be registered by instruments measuring in the NIR area. The second goal is to design graphic elements that are not recognized in the NIR specter, but are visible so that we can see them. And thirdly: to produce a "double image" with conventional graphic inks, but in such a way that each image is recognized only in the previously set wavelengths. This approach introduces modified learning on graphic arts separation where two independent images are joined in creating CMYK printing channels. The second image as a gray record is the desired black component (K) in the first visible spectrum image. The standard colour management ends in the visible space (1) but with the help of inks management, a second hidden image can be developed in the NIR space. Channel K acquires a new meaning. It is the carrier of its own information in image and text form.

Key words: infraredesign IRD, near infrared NIR, CMYKIR separation

1 Introduction

The conversion from a RGB (Red, Green, Blue) record into a CMYK record (Cyan, Magenta, Yellow, Black, most often carbon black K) for graphic requirements includes also some achromatic methods (GCR Gray Component Replacement, UCA Under Colour Addition i UCR Ander Colour Removal)(2). They take care of replacing CMY with K, the information about which has been extracted from the same image in question. Conventional colour management and computer programs offer separation with the participation of channel K in several discrete levels.(3)

If we separate colour tone V(treated as visible image), Figure1., coverage will be achieved for each channel separately, in a uniform tone over the whole space of this single-tone image. Before initiating the translation from RGB (2^8) into CMYK (%), it is necessary to decide which change of CMY towards CMYK we wish to achieve.

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$$V=\begin{bmatrix} R & H & L \\ G & S & a \\ B & B & b \end{bmatrix}, \quad \text{numerical: } V=\begin{bmatrix} 77 & 206 & 38 \\ 94 & 28 & -7 \\ 107 & 42 & -12 \end{bmatrix}, \quad (1)$$

For V colour tone (equation 1), Lab Values: 38,-7,-12, (Figure 1.) shows some possible K conversion set-ups: implemented profile-eurostandard coated v2

Table 1. Possible reproduction set-up coverages (â) for the observed colour V

set-up coverage (% â)	C	M	Y	K
None reduction (X_0)	77	58	47	0
Light (reduction)	78	50	42	21
Medium (reduction)	71	39	33	35
Heavy (reduction)	51	17	15	56
Maximum (reduction) (X_{max})	29	2	3	67

Any choice will result with the same V set-up in the visual spectrum, although the material composition of the CMYK channel will be different, but nevertheless – single tone. For each set of process inks, - the values are characteristic for them. The following set-ups are given for Xeikon digital printing: /medium: 58,24,14,56 and maximum Xmax: 33,6,3,78/

Uniform colour tone separation with the exterior grey scale picture as the K channel

The new way of separation is demonstrated as an extreme case. The first experiment uses two input images in a specific manner for CMYKIR separation. The first picture is only tone V (Figure 1., equation 1). The second picture (Figure 2.) sets the participation of the black component K in the separation: the conversion of RGB into CMYK(2) set-up. The second image (portrait SP, Gray scale, Figure 2, channel K following CMYKIR separation) will be visible in the NIR wavelengths.(4) The visual impression of such a reproduction is the uniform tone V. The portrait will be hidden behind the visual spectrum image.

It is possible to carry out the conversion of CMY for CMYK in an infinite number of ways for continuous values ranging from K=0 to K= Kmax. Possible values are given for the V colour tone regarding the conversion of CMY coverage components with increasing K to the maximum, with the goal to calculate the regression equation of continuous values for CMY and K conversion.

The X_0 do Xmax is set for tone V, with coverage (%) C_0=85, M_0=60, Y_0=50 respectively (numerical values are for the experimental profile frame: RGB Adobe 1988, CMYK: Euroscale coated v2).

Values C_1,M_1,Y_1 have been obtained with a regression analysis of approximate of square curve values, shown in Graph 1.

$$X_0=\begin{bmatrix} 85 \\ 59 \\ 49 \end{bmatrix}$$

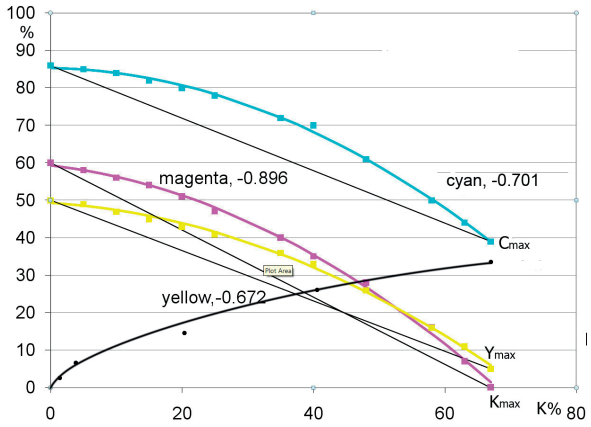
while $K_0=0$ and $X=X_0-E^*\begin{bmatrix} K \\ K^2 \end{bmatrix}$, (2)

Table 2. CMY coverages measured values, and C1M1Y1 from square equation (2, 3)

K	C	M	Y	C_1	M_1	Y_1
0(X_0)	86	60	50	85,39798	59,29791	49,29208
5	85	58	49	84,96145	58,02908	48,53471
10	84	56	47	84,03677	56,26738	47,37775
15	82	54	45	82,62393	54,01281	45,82119
20	80	51	43	80,72293	51,26538	43,86503
25	78	47	41	78,33379	48,02507	41,50927
35	72	40	36	72,09102	40,06587	35,59896
40	70	35	33	68,23741	35,34696	32,04440
48	61	28	26	61,05627	26,77155	25,52595
58	50	16	16	50,32249	14,27797	15,93932
63	44	7	11	44,22336	7,291876	10,54661
67(X_{max})	39	0	5	38,99259	1,34813	5,944720

where parameter E values are:

$$E=\begin{bmatrix}0{,}03849 & 0{,}00976\\ 0{,}20448 & 0{,}00986\\ 0{,}11151 & 0{,}00799\end{bmatrix}; \quad (3)$$



Graph 1. Continuous (reduction of) coverage C, M, Y depending on K for colour tone V and $C_0M_0Y_0$

The average drop of the conversion for CMY: -0.701, -0.896, - 0.672 respectively, deviates by far in respect to the the academic value amounting to -1. Even the slightest error outside the given equations will show in the CMYKIR separation (5) as an error. The real life inks seem like an enormous world of exceptions. The proposal of a single tone interpreted as a square equation provides a well hidden CMYKIR picture.

Figure 1. Hue of the tone VRGB

Figure 2. Gray scale portrait (SP)

The second image, portrait (SP) is shown as a gray scale, and is the basis for incorporating into the first image. CMYKIR separation joins two images according to relations (2) and (3) that describe the consistency of tone V .

The result is given in Figure 3 for all four CMYK channels. By joining all four separation channels a CMYK picture is produced which has a uniform content in the overall space, i.e. visually - the colour tone shown in Figure 1. On the other hand, each channel has its own coverage. A modified Figure 2 (SP portrait) is situated in the K channel. In the other separation CMY channels there is a difference in the portrait coverage from the K channel in respect to relations (2) and (3).

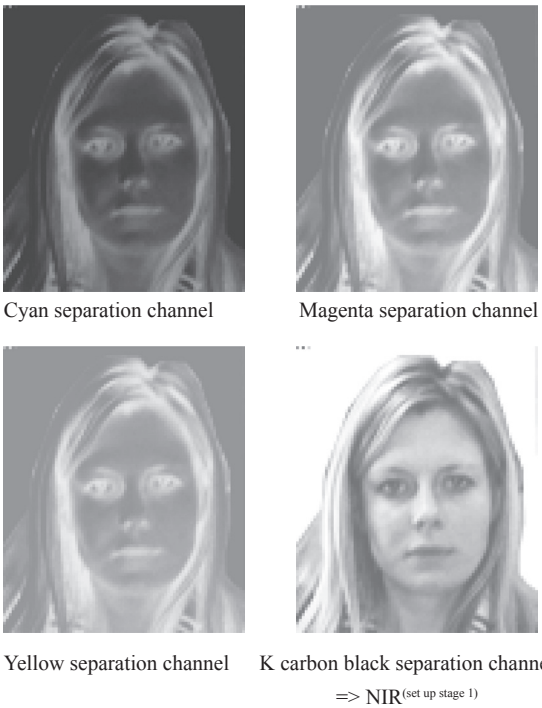


Figure 3. Content of C, M, Y and K separation channels

Figure 3 shows four conventional channels; CMYK(1). By joining those four channels (CMYK (set-up 1)) an image is created with only one tone (V) on the overall space, identical to Fig 1.

Figure 4. Hue of the colour V presented in CMYK mode

If this CMYK having four different values along its channels is translated into the RGB area, a uniform colour tone is produced on the overall image. If separation is continued from the newly-created RGB mode into the CMYK mode with conventional separation, the same tone V is produced, but all the CMYK(set-up 2) channels are with single tone values. In such a case all the initial set-ups shown in Figure 3 are lost forever.
By joining CMYK channels an invisible image is created, visually only a uniform V colour tone. The portrait is not observed in VS. However, it is recognized in the NIR wavelengths due to the plan to print the K channel with Carbon black that absorbs the NIR spectrum. Numerical data on Figure 3. are valid for the Euroscale ve coated coloursetting, whereas the tone achieved for other coloursettings is not as uniform, and the square equation parameters must be calculated all over from the very beginning.

Following the coloursetting change that had not been the basis for calculating the relation between CMY and K from relations (2) and (3), a partial appearance of the portrait in the VS and RGB mode will follow, and in CMYK(2) mode. Such experiments are a good test for evaluating the chosen coloursetting and its dependency on real life process inks and on the substrate material. Experimenting with different coloursettings in this example is ideal for having motivation to understand three different worlds in colour management: visual colours, colours on the computer monitor and material colorants printed on paper.

This example shows that any uniform colour tone can carry information that is not planned to be seen by the human eye. The area of application is enormous: military uniforms, flags, state symbols in the uniform and single tone space.

Discussion

CMYKIR separation using standard process inks, that can be used as steganographic, implies planning of inks composition that on the basics of given RGB value would produce continuous different values in NIR spectrum. That values can produce combinations from zero to its maximum, but preserving constant RGB values (graph 1). With process inks (combinations) its posasible to reach desired absorption in NIR spectrum. Minimum value (X_0) is the value containing only $C_0M_0Y_0$ values, besides conventional separation from RGB toward $C_0M_0Y_0$. Colour impression in that stage NIR instruments do not register. Carbon black maximum component for CMY substitution produces strongest absorption impact in NIR spectrum. At that point at least one of C, M, Y components achieves zero value. Let this state be described as C_{max} M_{max} Y_{max} K_{max}

4, Conclusion

Described procedure specifies and interprets achieving the process of displaying two different images, first visible, while second image, IR visible image utilises custom adjusted colour management and colour settings customised from the visible part of the spectrum image. Defined visible profile usage is nesessary, taking into account that unfavourable setting decreases IR separation efficiency and effect. Second image visualisation is easy possible with simple procedure and device, and also it can be numerically evaluated. As standard reproduction inks are commonly used, CMYKIR separation process can be obtained practically in any graphic reproduction process, and steganographic effect of the IR image is wasted by repeated scanning and digitalisation process.

Literature

1. Yoshi O. (2000) CIE Fundamentals for Color Measurements, In: Proceedings of NIP16: International Conference on Digital Printing Technologies, 16-20 October 2000, Vancouver, Canada, p. 540-545
2. Yule J.A.C.(2000) Principles of Color Reproduction, Pittsburgh, GATF Press, pp. 29-41
3. King J. (2001) Why Color Management, In Proceedings of the 9th Congress of the International Colour Association, 24-29 June 2001, Rochester, NY, USA.
4. Žiljak V., Pap K., Žiljak-Stanimirović I., Žiljak-Vujić J. (2012) Managing dual color properties with the Z parameter in the visual and NIR spectrum. Infrared physics&technology.[Online] 55(4) , 326–336 Avaible from http://www.sciencedirect.com/science/article/pii/S1350449512000230
5. Žiljak V., Pap K., Žiljak I., Žiljak-Vujić J. (2009) Upravljanje informacijama u infracrvenom dijelu spektra. Informatologia, 42(1), 1-9.