Design of Security Graphics with Infrared Colours

Ivana Ziljak, Jana Z. Vujic, Klaudio Pap

The color tone defined in RGB, HSB and Lab systems may be defined through C0 M0 Y0 K0 seen by the human eye but invisible in IR wave lengths. This color tone may be associated with the Ci Mi Yi Ki more broadly seen in wavelengths of the visible spectrum as well as in IR wavelengths. The Cm Mm Ym Km maximum possible response in the IR area is determined for every color. The double separation program uses two images. The first image is the one we see fully in the visible specter part. The second image is the pattern that has the role of a mask. The CMYK separation is controlled with the pattern in order to achieve the appearance and elimination of the first image's visibility in the IR area. The image element covering halftone values of the second image most often equals to zero or to the maximum value. All halftone values that fall into the area between the two listed extremes enable visibility gradation control in the IR specter. Each single color tone has its own gradient values for CMY components depending on the K component increase. Each components gradient depends on the C, M and Y values that compose the observed color. The paper contains the gradient coefficient matrix with three independent variables for each color. The parameter values are proven by linear regression and on basis of print measuring. The once determined gradient parameters for the observed printing technique and the corresponding process colors provide unlimited application of IR control in colored images by using only process toners.

Introduction

Document and securities graphics are a motivation for design, learning and application of extreme printing techniques. The hidden information made by infrared colour is present on all graphic products, cards, packing material, documents and securities. We can reveal it by scanning it under wave lengths that are in a much broader scale than those that we see in broad daylight. Security printing is an area where there is additional production by using special paper as well as process and spot colors. This paper is an introduction into revealing new security procedures. In security graphics a print is observed under ultraviolet (UV), infrared (IR) light, slanting (EPI) light and under transparent light. This is a much wider area in comparison to the one treating only light wave lengths visible to the human eye. Security printing design unites tactile ink application, programming of individual rastering, control of UV and IR ink application, simultaneous printing with a high quality register.

We approach security graphics by using specific characteristics that come out of the possibility of programming for digital printing: a print's individuality, color mixing programming, multi-layer application of toners, controlled ink separation for printing, simultaneous printing on both sheet sides. Security graphics are described as graphics where there is application of inks that have special characteristics when reacting to UV and IR light wave lengths and they can not be purchased in the free market. It is shown that by programming the graphic element structure a better quality protection can be achieved by using conventional inks if one knows more about their structures. There is preliminary analysis of each ink and its behavior in the invisible specter part. The programmed graphics that include a combination of UV, IR and conventional inks expands security printing with a higher degree of security characteristics.

Elements taken over from the field of top-quality security graphics, as for instance in documents and securities are used also in commercial graphic design for product security i.e. brand security, but also in order to have exclusive design. Such application is most often in cards (tickets, membership cards, credit cards), in wrapping material (medication packaging material, cosmetic product packaging, food packaging, technical goods packaging), in certificates (diplomas, school certificates, legal documents, public notaries' verification, letterheads, ownership documents), on bank documents (payment slips, checks, credit contracts, payment receipts), on stickers (labels on glass and plastic packaging material) on postal stamps, on gift coupons. Hidden information made on basis of top-quality design, i.e. planning and design may be applied also in designing posters, magazines, brochures and books to have special visual effects.

In practice up to date security graphics have developed by applying special toners or extreme printing techniques reserved only for security printing, as for instance Infrared toners, UV toners, intaglio printing, steel die printing, security paper, kinegram.

Infrared graphics

The existing color system (HSB, Lab, Cie, RGB, CMYK) does not deal with the problem of how a color tone was produced. This study is about changes of color tone depending on light sources from 254 to 1000 nm and the angle of observing a print. This may be applied in proving the authenticity of a print, paper and color. The color tone, if observed in daylight (400 to 650 nm) may be achieved in many ways. Information on color structure and generation is deeply hidden. Various prints with color generation may give the same color tone impression to our eye, the same graphics. In respect to this we are not certain whether the print had been made with original inks, on the same paper and the same production techniques. Each color component from the original color it was generated from gives a separate reaction to UV and IR light, and this is the initial point for proving its authenticity. Simultaneous application of different light sources on the print reveals the presence of the following: differently mixed colors, combinations of various print techniques, software generated graphics, simulation of tones generated from different sources.

Designers usually pay more attention to the graphics they see in daylight. In doing this they do not plan the security system and observation under IR light. Only in some cases do they apply invisible ink. Experts in the field of securities include additional mixing of inks that change under UV light. Knowledge in respect to the IR printing ink system is a new area in printing. Programmed designing is thus opened, aimed designing and graphic product coded protection.

Contemporary applications plan IR security with spot colors, with a mixing the tone prior to printing. The same situation responds under IR light and the other that does not respond under IR light. The design for controlled response under IR light is discussed for colors that in this sense complement each other during printing. There is also research work done on the matter of obtaining a print with a positive reaction to IR light in the whole coloring specter of one and the same image. And there is programming of the color tone with controlled doses of response under IR light by using only the CMYK scale.

Experiment results

Study of many inks in the IR light has initiated security graphics programming by using the said properties. Co-workers on this task have developed algorithms of the visible RGB system separation for graphic make ready of spot and process inks using information on the light response in the IR area.

The color that responds in IR light (for instance the conventional black or spot green that we have available for printing with Xeikon) is the corresponding one for complex design. The goal is to use this color's property for information exchange under IR light. Programming includes layers of two or more colors having the same tone (in daylight) but having totally different responding under IR light. Scanning of prints under IR light reveals many new areas of application in security printing. Proposals have been made for application standardization. Each color is observed as the potential one in applying protection to a graphic product or as the beginning of making a new individual solution in the general document and securities security area.

Process colors react differently in the IR area. Offset inks, inkjet colors, digital printing toners have their own visibility characteristics in the transition of visible and soft IR area and the radiation area exceeding 700 nm. 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 seen in the IR area. A different transformation algorithm of RGB towards CMYK is applied to each pixel (or vector graphics line element). The print color tone must be independent in respect to addition or subtraction of certain components. The characteristics of black observed under 1000 nm is used and the characteristics of colors invisible over 700 nm. The visible area between 360 to 650 nm must remain the same as if no special separation had been programmed. The black color is incorporated into those image parts that we wish to see under IR lighting. Image elements that we do not wish to be seen in the IR area are built of CMY components only. We extend the theoretical separation settings with experimental measuring results acquired on targeted prints with which security graphics are going to be carried out. It has been determined for certain printing (Xeikon) that the curve of dependability on replacement with a black toner may be set in a satisfactory manner for each color comprising all three CMY components. Under the term «all three components» it is understood that the IR response intensity will be equal to the presence of the least present one of the three CMY components.

The term «replacement with a black toner» may be «dosed» from minimum to maximum values depending on the previously mentioned minimum component system and characteristics of the toner visibility in border area of the «soft IR». Transformation of RGB into CMYK comprehends reaching the same values of all RGB, HSB and Lab system parameters for all areas of K component altering (up to its maximum) in the CMYK system. Thus it is provided that the image is identical in the lighting visible area, i.e. independency in respect to the achieved RGB/CMYK separation.

A mask is placed on a multi-color image by which the image is separated into visible and invisible areas under IR radiation (Figure 1). The mask can be a grayscale image or a black-and-white drawing.

Fig. 1
a) Original,
b) grayscale mask,
c) IR result

The aim of our innovations is managing colors that are seen in the infrared area on the planned location with planned intensity. The aim is to create an image inside the image to be recognized separately in two different states.

Fig. 2
Image of nature and vineyards under daylight

The image in Fig. 2 consists of two real images: the first image is the image of nature, and the second image is a portrait. Portrait, as the second image is not seen in daylight. It is gradually rising in the IR spectrum (Fig. 3).

Fig. 3
Image of nature scanned with an IR camera under 695 nm barrier filter – transformation of impression in IR graphics

The integration of two images can be seen at the transitional wavelength ranges in the infrared region. From the first image remains only cyan color. The other image, portrait, has become a combination of dark parts of the first images from the cyan channel and the intensity of the second image. Gradual increase of IR wavelengths leads to emphasizing the second image, and losing all the CMY process color channels from the first image. Image of nature, as in full daylight, completely disappears in the infrared area over 700 nm. The novelty of the method is the possibility of targeted design images for the IR conditions.

Joining of two real images is subject to the rules. The first image must be seen in the joining image independently without any indication that it has built-in infrared intervention. At daylight, the first image and the reproduction give equal experience. In the infrared reproduction the aim is to achieve that the second image is visible as more realistic. Separation process by a set theory does not allow refinement in the perception of the first image. Therefore, one can see only those pixels from the IR image which are lighter than possible replacement with the IR colors. At 1000 nm IR image (Fig. 4) there are some details of nature that were very light in the first image.

Fig. 4
Image of nature scanned with an IR camera under 1000 nm barrier filter – the portrait is visible

In the figure 5 the mask is a black-and-white drawing. 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. The image part planned to be visible in the IR area responds depending on intensity.

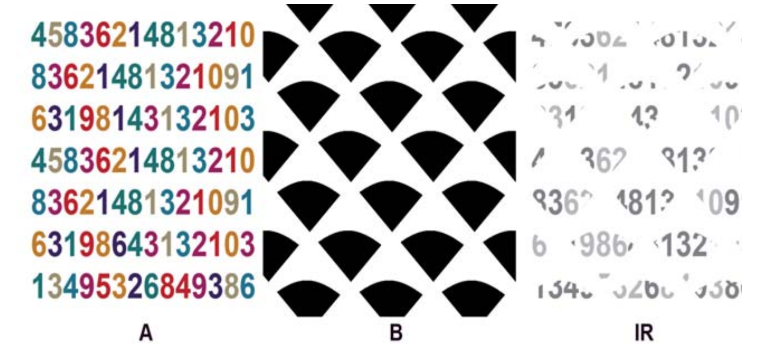


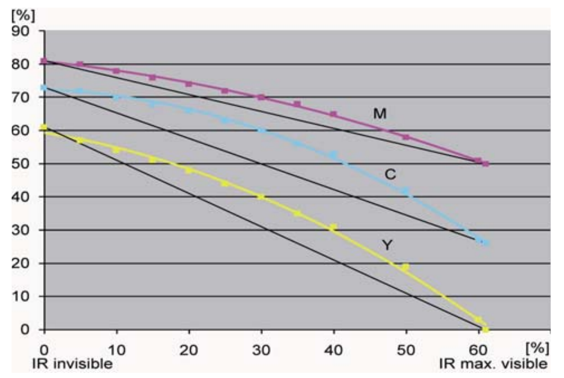
Fig. 5
a) Original,
b) black and white mask,
c) IR result

Pixels printed with CMY colors (Xeikon, without black toner) are not visible under IR light over 700 nm. Pixels printed in CMYK colors (K is above zero) are visible under IR light depending on the K component presence. Adjusting separation is clear from the theoretical point of view. Adjusting separation for certain real colors with the goal to have a uniform impression of color tone under daylight (DL) is the subject of this paper: setting the parameters for correcting the transition of RGB into CMYK/CMY print.

Measurements results and gradient coefficients

Research work has shown that it is possible (taking into consideration acceptable tolerances) to determine mutual relations for a wide specter of coloring. Gradient coefficients are defined as linear regression with many measurements. The decrease coefficient and the decrease function of each CMY color is determined by the presence of all four colors. Relations behave well within the allowed limits. The first limit is determined by the value null on the black component. The second limit is determined by the moment when one of the CMY components drops to the value of null. That point may be even lower or higher than the value determined on basis of the minimum of a C0 M0 Y0 value, and in cases when the black component equals to null.

Fig. 6 Graph of the color tone HSB: 322,44,36



Any color with positive values in all RGB components but less than maximum is suitable for IR effect application. Figure 6 shows graph of the color tone with constant values in HSB: 322,44,36; in RGB:92,52,77; and in Lab:28,22,-8. realized in the wide CMYK area. Visibility of IR radiation depends on black toner presence. Increasing the black componet K part is followed by decrease of CMY components on basis of the following relations:

$C = -0,01123\ K2 - 0,06808\ K + 72,982$
$M = -0,00449\ K2 - 0,229\ K + 80,85$
$Y = -0,00981\ K2 - 0,35075\ K + 59,37$

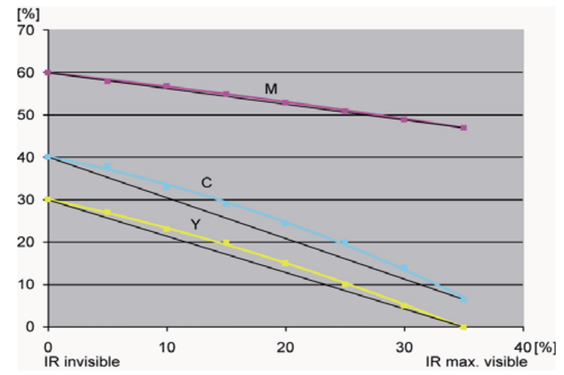
The IRC method (InfraRed Control) takes the values K in image B (mask, sample) with standardization in the range from Kmin to Kmax. If the mask is composed of only black/white pixels then only the C0 and Cmax values are of interest; i.e. M0/Mmax and Y0/Ymax given through coefficients in direction based on two points:

$C = -0,77\ K + 73$
$M = -0,5082\ K + 81$
$Y = -K + 61$

Such interpretation through a straight line could be used for the whole area if deviations in RGB/HSB/Lab systems are tolerated.

Each different tone color has its own coefficient values regardless of the fact whether the color is described by a polynom of the first or second degree. An analysis of yet another color is given as an example with the following values: HSB: 334,28,64; in RGB:163,118,138; and in Lab: 55,20,-4.

Fig. 7 Graph of the color tone HSB: 334,28,64



Graph in Figure 7 shows CMY changes depending on K:

$C = -0,001167\ K2 - 0,54\ K + 40$
$M = -0,0019\ K2 - 0,305\ K + 60$
$Y = -0,00762\ K2 - 0,6\ K + 30,08$

or as a direction through the initial and final points:

$C = -0,957\ K + 40$
$M = -0,486\ K + 60$
$Y = -0,857\ K + 30$

Two tone colors that have been shown (Figure 6 and Figure 7) have completely different coefficients. In order to create a unique IRC separation algorithm, it is necessary to have an analytical relation that includes a wide range of tones, with a wide specter of coloring. Measurements of over one hundred color tones have shown a system quality in polynom parameters that describe the interdependence of CMY and K for IRC separation. The general dependence in respect to the researched digital printing toners has been determined on basis of multi-regression analysis. IRC separation has been therefore determined on basis of two images: the original (A) and the mask (B) with the goal to have controlled appearance of graphics in the IR area.

As and addition to the discussion about the second image – the mask, it may be stressed that it can be only an algorithm, generated as its own security. Generating may include all the discussion on pseudo-random sequences with parameter individualization in such algorithms. In this way the discussion on security, digital printing being applicable in multi-color with IR designing is extended significantly.

Conclusion

Research on the characteristics of printing process toners in infrared light has enabled the defining of translation relations of the same color tone in two areas: the print as only seen by the human eye and the same print as we see it in daylight and infrared light. The «double separation» algorithm enables programming of one print segment that will appear under IR radiation only, and will not alter our impression of the color tone or any other image element as seen in daylight. The novelty in this paper is introducing the «dual separation» algorithm for conventional process toners visible only under daylight (DL) or in the wider areas: DL and IR areas.

(first received 22.04.08)

Reference

1 . Žiljak, Ivana; Pap, Klaudio; Žiljak-Vujić, Jana: Alternative Infrared Solutions for Security Graphics with Digital Print, 8th International Conference on Security Printing & Alternative Solutions, Ljubljana, Slovenija 2008
2. I. Žiljak, J. Žiljak Vujić, Elaboration of design of screening elements, 8th International Design Conference Design 2004., Dubrovnik
3. J. Žiljak, V. Vančina, D. Agić, I. Žiljak, K.Pap:"New screening elements in multi-colour printing for special purposes ", 30th International Research Conference of IARIGAI, Dubrovnik, 2003,
4. Žiljak, Ivana; Pap, Klaudio; Agić, Darko:" Behaviour of Some Custom Programmed Screening Elements in Various Printing Systems", 32nd International Iarigai Research Conference, Haikko Minor, Porvoo, Finland2001

Ivana Ziljak, PhD

University of Zagreb, Faculty of Grapic Arts, Getaldiceva 2, HR-10000 Zagreb, Croatia

ivana.ziljak@vip.hr

Jana Z. Vujic, PhD

Zagreb Polytechnic for Technical Science, Vrbik 8, HR-10000 Zagreb, Croatia

janazv@tvz.hr

Klaudio Pap, PhD

University of Zagreb, Faculty of Grapic Arts, Getaldiceva 2, HR-10000 Zagreb, Croatia

klaudio.pap@zg.t-com.hr