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POLYTECHNIC & DESIGN Vol. 6, No. 3, 2018.
DOI: 10.19279/TVZ.PD.2018-6-3-14
DOI: 10.19279/TVZ.PD.2018-6-3-04

DOUBLE QR CODE WITH CROSS COLOR TWINS FOR VISUAL AND INFRARED SPECTRUM

DVOSTRUKI QR COD S UNAKRSNIM BLIZANCIMA BOJILA ZA VIZUALNI I INFRACRVENI SPEKTAR

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Abstract

Hidden graphics for visual close infrared (VIS and NIR) spectrum consists of two pairs of twin pairs of interlacing colors creating quadruple dependency as VZ graphics. Two-ton color dye absorption spectra are introduced, extending to their twins. Colorant recipe that are made up of four process colors are enclosed. Mixing the dyes is interrelated depending on the recognition in a visual and close infrared spectrum. Two graphics are independent QR Codes that are located in the same space. The first QR code is readable in the visual (V) spectrum and the second cod is detected by an infrared camera at a wavelength of 1000 nm. The IR camera does not recognize, does not register the first V code. Each code begins with quadratic elements of two extreme coverage: black (K) and white surface (W). Overlapping two independent codes V and Z, determines four combinations of coverage, with which two colors are realized. Gray and Cyanosis gray colors form four twins according to VZ procedures in the VIS and NIR spectra.

Keywords: *dual QR code, quadruple twins, INFRAREDESIGN®, camouflage clothing*

Sažetak

Skrivena grafika za vizualni bliski infracrveni (VIS i NIR) spektar sastoji se od dva para blizanaca boja s međusobnim uređenjem stvarajući četverostruku zavisnost kao VZ grafika. Prezentiraju se spektrogrami apsorpcije svjetla za dva tona boje s proširenjem na njihove blizance. Priložene su recepture bojila koje su sastavljene od četiri procesna bojila.

Miješanje bojila je međusobno ovisno za prepoznavanje u vizualnom i bliskom infracrvenom spektru. Dvije grafike su nezavisni QR codovi koji se nalaze na istom prostoru. Prvi QR cod je čitljiv u vizualnom (V) spektru a drugi cod se prepoznaje s posredstvom infrared kamere na valnoj duljini Z od 1000 nanometara. IR kamera ne prepoznaje, ne registrira prvi V kod. Svaki kod počinje s kvadratičnim elementima dvije ekstremne pokrivenosti: crnim (K) i bijelim površina (W). Preklapanje dva nezavisna koda V i Z, određuje četiri kombinacije pokrivenosti a s kojima se realiziraju dvije boje. Siva i cijanozno siva boja formiraju četiri blizanca prema VZ procedurama u VIS i NIR spektru.

Ključne riječi: *dualni QR kod, četverostruki blizanci, INFRAREDESIGN®, kamuflažna odjeća*

1. Introduction

1. *Uvod*

Colors for the printing industry have duality that initiated the emergence of a theory and practice called INFRAREDESIGN®. Process colorants; cyan, magenta and yellow, do not absorb light in the near infrared spectrum. In contrast, carbon black ink absorbs deeply in the NIR area, which is the basis of many ideas for extending security graphics in the application of all printing technologies. INFRAREDESIGN is a special of “gray component replacement” (GCR) method by which Component K is to be pre-dispensed prior to the separation of printing ink dyes. Graphic product dualism manifests itself as hiding and selecting information.

Figure 1 *Two codes for the V and Z records*
Slika 1 *Dva koda za V i Z čitanje*

Experiments with hiding QR codes are successfully applied to transparent materials; silk and polypropylene [1]. The merging and resolution procedures of two images intended for visual (V) and NIR (Z) spectra were published in symposiums and journals with simulation models for security masking [2]. Digital graphics technology has been expanded due to the individualization of each printed copy. There is a new approach to document and valuable paper [3]. Each color is solved in several ways by taking into account the replacement of carbon black with other process C, M, Y dyes [4]. The design of a protected product label, for example is the result [5]. The dual design of postal stamps with additional information that is only reflected in a "night view" when an infrared camera is applied [6]. Area Informatics has received new tools that are presented in this paper. The idea to design the QR code as an "invisible sign" as extended information rose after many years of experiments and real applications. The first dual display of hidden QR codes was published in the journal "Informatology" [7].

Cameras have been developed as refurbished cameras with visual-light filters that pass through the NIR spectrum. The filters are calibrated for blockage at 1000 nm, which is referred to as "Z" in this paper. Two ZRGB cameras record two states simultaneously [8]. New cameras with ten filters allows to study precisely colors and dyes as well as the numerical and graphical interpretation of light absorption in the visual and near infrared spectrum [9]. New discoveries of dyes and their mixtures were found, which is a stimulus for duality in visual applications [10].

Camouflage of clothing, especially military uniforms on canvas and leather, contains invisible data [11].

This leads to designing multi-information designs when the clothing is viewed with "Night Vision" cameras [12]. For instance, the recording of works of art is carried out before restoration works and using forensic methods to determine the color composition in fine art [13]. The merge of the topic "art and science" is illustrated as a new art direction in creating double images and hidden drawings [14]. Two light spectra, two images, double information initiated various suggestions in graphic design. This paper presents a hidden marking in coding technology.

2. Connecting Two QR code with the IRD method

2. *Spajanje Dva QR koda s IRD metodom*

Codes are not equal in size nor content. Codes will be printed with four-color process printing. The first V code is located in the channel cyan (C) and the other code is placed in a black channel (K) that absorbs the NIR spectrum at the beginning of the two code merging technology.

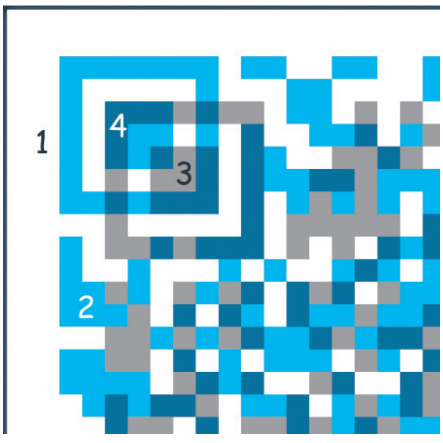

Figure 2 *A part of preparing two codes for VZ separation*
Slika 2 *Dio pripreme dva koda za VZ separaciju*

With two overlaps, the two codes generate four different color tones marked 1, 2, 3, 4 (Figure 2). These colors camouflage each other making four pairs of twins. The color twins are subordinate to the common requirement of mutual hiding. It is commonly found that white areas surround the black box squares. Graphic preparation for printing will determine camouflaging gray in places where the codes do not overlap.

Table 1. *Plan C, M, Y, K color prepared for VZ separation and printing*

Tablica 1. *Plan C,M,Y,K boja pripremljeno za VZ separaciju i tisak*

Početne vrijednosti bojanja dva koda: c, m, y, k	
1.Pozadina, bijela okolina oba koda	0,0,0,0
2. Pokrivenost vizualnog V koda	99,0,0,0
3. pokrivenost sakrivenog Z koda	0,0,0,40
4. Zajednička površina V i Z coda	99,0,0,40

3. Four-color twin arrangement for two colors

3. *Četverobojni raspored blizanaca za dvoje boje*

Four colors (Table 1) will be created with four dyes that will only show a two tone color according to the method of creating VZ twin dyes: in gray and blue. The environment will be gray, consisting of only C, M, Y colorants in the VZ code system. In figures, it is a composition: C = 25%. M = 23%, Y = 40% coverage. This gray tone [10] is exactly as gray as the same grayness achieved only with carbon black 40% coverage (printing on white paper with OKI 5421 toner).

The color definition begins with a dye that will display the NIR - ZRGB camera with minimum coverage so that the camera registers the Z code and respectively decodes it as a hidden code. In this paper, it was determined that it was a"carbon black" (K) dye from a series of colorants from printing technology (color no. 3). Color K40 is located in the third and fourth colors (Table 1). There are certain other dye components to achieve the camouflage of the Z code. The surface is gray in places where there is no two codes covered. However, it only consists of cyan, magenta and yellow process dye that the NIR camera does not register (color No. 1).

Twins are introduced in order to maintain the desired color and the places that overlap with the two codes. Two gray colors and cyanic gray define four colorants with the condition that four twins are placed with them. An expanded twin arrangement was created, which was termed "Four-color twin colors and dyes" (Figure 3). Visual spectrum and twins by NIR -Z light distinguish twins.

First Schedule: Two colorants have the same minimum light absorption at 900 nm in the NIR spectrum and differ in V spectra (color 1 and 2).

The second (color 1 and 3) and third twin arrangement (colors 2 and 4): Two dyes are the same in the visual spectrum in the range of 400 to 700 nm, but differ in the absorption of infrared light. Fourth Twin Schedule: Two colorants equally (maximally) absorb Z-NIR light at places overlapping the V and Z codes (colors 3 and 4).

Figure 3 shows the relationship of cross-positioning four twins. Two and two twins have some common values. Z_{40} twins are equally responsive to NIR cameras. They see the QR code reader if the reader points to the camera screen that selects the NIR spectrum. Z_0 twins do not respond to NIR cameras. V_{blue} twins blink to our eyes as blue. V_{gray} twins camouflage the conflict between two QR queues.

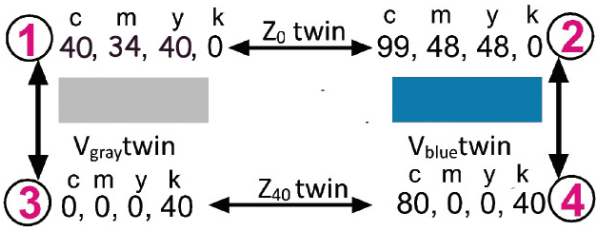

Figure 3 *Two colors in the arrangement of four twins colorants*

Slika 3 *Dvije boje u rasporedu četiri blizanca bojila*

The color is the same as that of a dyed color only with a visual twin (color 4) in places where two codes are covered. Surfaces covering the two codes ensure that the Z code has a 40% coverage with carbon black ink to allow the infrared reader to register that Z code. The initial coverage value of cyan dye V twin decreases at this point.

It initiates a new color tone for the V twin in those places where there is no overlap with the Z code. V twin becomes darker because M and Y dyes are added.

The conditions for mixing colors to extremes example contrast to the four-twins:

Equivalence of color tones: 1 and 3, as a gray tone

Equivalence of visual color in places overlapping V and Z codes: 2 and 4

Restrictions and the first process have rules and recommendations:

maximum C in color 2.

Default value K in color 3 and 4. (40%)

Minimum colorant values of C, M, Y in colorant 3 (zero value)

Minimum colorant values of M and Y in colorant 4 (zero value)

Only two colors are displayed after printing (Figure 4). There are four twin, different process colors, and four-color arrangements inside which is shown in Figure 3. The NIR camera will only deliver V (gray) twins that have a 40% carbon black color coverage. It is sufficient to read the "hidden" code; hidden to the naked eye.

Figure 4 *Dual code with matching twin colors and dyes*

Slika 4 *Dualni kod s pripadnim blizancima boja i bojila*

The text in V code is:
http://www.nada.ziljak.hr/Katalog-Mimara-2018.pdf
Infrared ART, Muzej MIMARA, Zagreb, Croatia, Nada Ziljak,

The text in the hidden Z code is:
http://www.nada.ziljak.hr/VIS-NIR-spektar.pdf
Galerija Sv. Ivan Zelina & FotoSoft, Croatia,

4. Color spectrum for double code

4. *Spektri bojila za dvostruki kod*

Different printing technologies using IRD methods require accurate dye twin color determination when it is intended to "completely hide" Z images. Hiding is not accentuated neither crucial in duplicate code execution, therefore, it is possible to deviate from the stark invisibility of the Z picture. Numerical values of color twin differences (DeltaE) may be greater than 3. The phenomenon of hiding is subordinated to code readers that have no strictness today compared to eighties time in the last century. A graph of light absorption in a visual and near infrared spectrum is derived for each pair of quadruple twins. The chart information will refer to the components of process color dyes if it is determined that QR code readers have a delay in recognizing the information they carry.

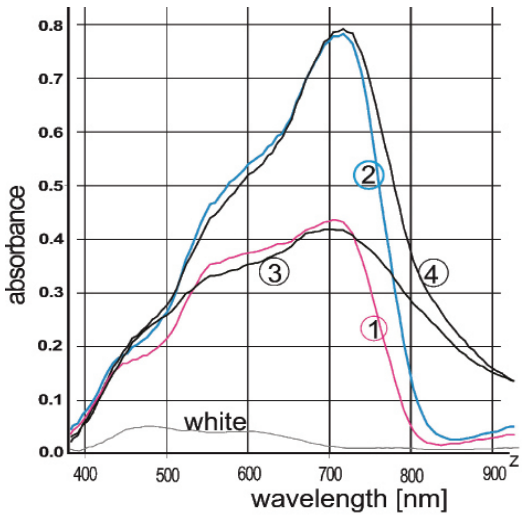

Figure 5 *Two pairs of twin spectra*

Slika 5 *Spektri dva para blizanaca*

Two gray colors of the same tone; no.1 and no. 3 camouflage each other in visual light. Color no. 3 absorbs NIR radiation and it reveals its part of Z graphics.

The arrangement the spectrum of colors and colorants of twins is an iterative experimental work. The uniformity of the visual twin charts depends on the material and the dyes with which the printing is performed. It is suggested to consult the spectral light absorbing graphs of each component in particular, which are published in a journal article Polytechnic & Design 2017 [10] to arrange the process of color components.

Spectroscopy identifies two recognition areas: the first visual code V in the range of 400 to 750 nm and the second Z code in the range of 850 to 900 nm. Dual camera ZRGB [8] will record parallel separate and recognize two codes.
Spectrograph 1 is an empty surface not visible with the Z camera. It is not visible to the first V code reader. It is a gray color with coverage of C, M, Y: 40, 34 and 40%. This gray camouflage color no. 3. Spectrogram 2: The surface of the first V code, where the surface of its squares is, has the maximum value of the cyan component. Other colors M, Y have a coverage of 48 and 48%.Spectrogram 4 is the area where the first QR V code and the second QR code Z jointly cover their dark squares. The value of cyan is reduced to 80%. Coverage is compensated with carbon black dye for easy code reading and the uniformity of the coverage of the first code across the entire chart. Spectrograph 3 interprets the surface of the Z-hidden code that is invisible to the naked eye. The influence of gray with cyan and magenta is reduced. The "3" graph in the visual spectrum is significantly lower, rising rapidly and ending with the 0.15 absorption value in the NIR spectrum at 900 nm.

The application of dual QR codes depends on the material being printed on, dyes and the technology of their display. Code Readers allow twin color differences to DeltaE with a value of 5. Duplicate coding experiments provide recommendations to the differences in color components for four-twin twins. There is a small difference in the code on the computer screen. Adjusting and changing the coverage formula takes place in the first step only for colorants M, Y. The first trim is in the third color that carries the information for the NIR record (Z cod), where there is no overlapping of the V and Z codes. The following adjustments are surfaces where there is no V or Z queue (first color).

Altering the C (cyan) value would be justified only if no twin dyes could be achieved with the changes of the M and Y dyes. The adaptation procedure is performed only after printing, trial printing and by observing the material where dual codes are displayed. Observing the phenomenon of hiding codes on a computer screen cannot measure for evaluating the quality of mutual concealment codes after their printing.

5. Reading two codes
5. *Čitanje dva koda*

Codes consist of a network of color aggregates that have both blank and covered areas as black squares typical of the QR code. Two code, V and Z, in the same place are separated in the observation of visual and near infrared spectrum. It is proposed to paint the Z code with carbon black of 40% coverage. This is sufficient to allow the dye to be recognized by the infrared camera without disturbing the readability of the first V and the code intended for recording in the visual spectrum.

Figure 6 *Reading QR (Figure 3) codes in the V and Z spectrum with the ZRGB camera*

Slika 6 *Čitanje QR (slike 3) koda u V i Z spektru sa ZRGB kamerom*

The second way of reading V and Z images is with a computer screen during the duration of the animation that imitates losing and flashing in the space of 400 to 1000 nm (Fig. 6).

***Figure** 7 The transition animation, of V and Z codes with filter blockages*

***Slika** 7 Animacija prijelaza V i Z kodova s filter blokadama*
http://jana.ziljak.hr/GalleryQR01.mp4

The transition animation from the VIS and NIR spectrum (Fig. 5) is stopped at a 680 nm light absorption. There is no information on the yellow component of the printing ink [12]. The remainder is a little magenta and the cyan color is at maximum absorption.

6. Zaključak
6. *Conclusion*

INFRAREDESIGN® is an expanding product protection technology. Two QR Codes are mutually hidden and together carry additional product information. The second code is an "invisible sign," extended information, security graphics. Codes are executed in different colors that enhance the design. Codes are executed on different materials with process printer dyes. A new color mixing technology based on the idea of four pair pairs of color dyes for just two tones is introduced in this paper.

The filling of blank spaces in the QR code is done with the C, M, Y dyes that the NIR camera does not see. These fills do not trouble the NIR camera to recognize the concealed Z code, which is made with carbon black. In this way, the image of the hidden code is completely obscured.

There is enough dual photo ZRGB camera to decode both content codes and to register as split photos. Pictures V and Z are read with "i-nigma" which is for instance on a phone. The innovative solution is protected against photocopying.

The two codes differ according to the percentage structure of each process dye. Printing can also be carried out with four color spots. Their compositions are adjusted due to differences in the Z area. The lowest difference in brightness for two pairs of twins is determined by DeltaL> 60 (L * a * b). The minimum values for the colorant no. 1 are 30, 30, 30 per cent coverage of C, M, Y.

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7. *REFERENCES*

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