Hidden infrared graphics on a painted canvas

JANA ŽILJAK
Department of Information Technology
University of Applied Sciences
Vrbik 8, 10000 Zagreb
CROATIA
jziljak@tvz.hr

LIDIJA TEPEŠ GOLUBIĆ
Department of Information Technology
University of Applied Sciences
Vrbik 8, 10000 Zagreb
CROATIA
ltepes2@tvz.hr

DENIS JURETIĆ
Faculty of Graphic Arts, University of Zagreb
Getaldićeva 2, 10000 Zagreb
CROATIA
djurecic@grf.hr

VILKO ŽILJAK
University North, Varaždin
104. brigade 1, 42000 Varaždin
CROATIA
vilko@ziljak.hr

Abstract: A hidden graphic has been put on a painted canvas. Innovative printing method is based on color twin pairs that are the same in the visual spectrum but different in the near infrared area. The differentiation of color pairs is being performed with cameras that are all around us with the purpose of "security surveillance". A dependence of light absorption on the wave length between 400 and 900 nm has been established for each pair of dual dye twins. INFRAREDESIGN® technology advancement respects the original canvas color from the basic textile production. Spectrography has been measured on the colored green canvas that has undergone multiple experiments and they have been expanded to the black canvas. A new mathematical model has been found, as a linear regression of the near infrared Z light absorption dependence on the visual V spectrum. Hidden infrared images of sights in the city of Zagreb are a new way of creating security graphics and creating individualized protected clothing.
Key words: infrared painting, VZ prepress separation, dye twins, hidden image, VZ textile dyeing

1. Innovative hidden design

A procedure of designing invisible information has been developed as a new way in the area of print and reproduction on canvas materials. The first results of the double graphics have appeared on documents performed with digital print on Xeikon [1]. Print on transparent polypropylene materials with hidden information [2] has initiated new research in the field of VZ infrared printing on leather, silk and especially on canvas. Dependence relations on the coverage of process dyes have been established: cyan, magenta and yellow with 40% coverage of carbon black dye on process dyes without carbon black dye. In this

paper the coverage of carbon black dye has been reduced to 40% of coverage considering that the green canvas has a property of strong ink absorption in jet digital print. A general printing theory with dye twins has been given in the paper [3] with application on documents performed with safety papers. In this paper the procedure of connecting two independent images V (visual) and Z infrared gray image is being expanded to dyed surfaces all the way until black. When printing to a black canvas that does not have a visually dyed image, a hidden image is being performed that is being detected with a ZRGB camera. The research includes the application of IRD in the field of camouflage design in nature. IRD procedure of VZ separation of printing dyes is being evaluated by a spectral analysis with a forensic instrument [4].

Figure 1. NIR camera on busy intersections.

Cameras will distinguish "infrared designed dresses" that carry different information for two separate spectral areas [5]. The dresses shown in this paper (Fig. 2) use IRD forensic camera [6] u in few blockades from 400 to 1000 nm.

The cause for this paper is an IRD idea based on creating double images on clothes. A precondition to that are cameras that are part of our daily life. Security in the city and private area is based on infrared cameras

Figure 2. Jacket in NIR an orchard

.

For example, only in Zagreb there are one hundred thousand installed cameras, both public and private.

We decided to use a dress to convey the desired message and/or information. By this we are showing that a clothing item can be a very important factor because, in combination with IRD, it can convey a targeted cryptic message invisible to human eyes.

The importance of the information itself does not need to be particularly highlighted. With a double image, in this case on clothes, we can convey information because a camera on the street, an intersection or at home will recognize it. Something that is at first sight invisible to the eye, the camera "sees" and conveys. For example, in this way we can convey a promotional, political or a private message, by the means that are within our reach – in this case by clothing items and a camera.

2. Twin dyes for 40% coverage with carbon black

The precondition of creating a double image is an interdisciplinary association the knowledge from the field of graphics, mathematics and informatics with the intention of conveying a message from the field of design, art and language, a message that is invisible to the naked eye. In order to create a double image and by that a transfer of NIR designed information, adequate knowledge from all the stated scientific disciplines is necessary.

Each color tone is being performed in the print in two different compositions with process dyes: Cyan, Magenta, Yellow and Black. The first dye composition, called V (visual) does not have positive properties of NIR radiation absorption. The second dye (of the same tone as the first dye) has a positive response of NIR radiation. In this paper the second dye is called Z dye, and after that also the cameras that distinguish V and Z dyes. We have introduced a measure of NIR light absorption difference to 900 nm called ΔZ. In the visual spectrum (400 to 700 nm) both dyes have the same spectrograms. The small difference between V and Z dyes in the visual spectrum is being marked with an acronym ΔE according to the conventional colorimetric theory. We have introduced a parallel recording of visual and infrared nature contents as well as art paintings. Such recording, such films are being called VZ as parallel observation, studying of two states of matter.

For the purpose of this paper we are showing spectrograms of two dyes (Fig. 3) in the range from 400 to 900 nm. Brown color (dashed) has the following CMYK values in %: V: 51, 60, 99, 0 and Z dye has been given with the values 14, 33, 71, 40. Green color has the following V values: 68, 43, 99, 0, and Z dye has been given with the values 40, 4, 59, 40.

Z1 i Z2. We have divided the NIR light area into two parts: Z1 and Z2.

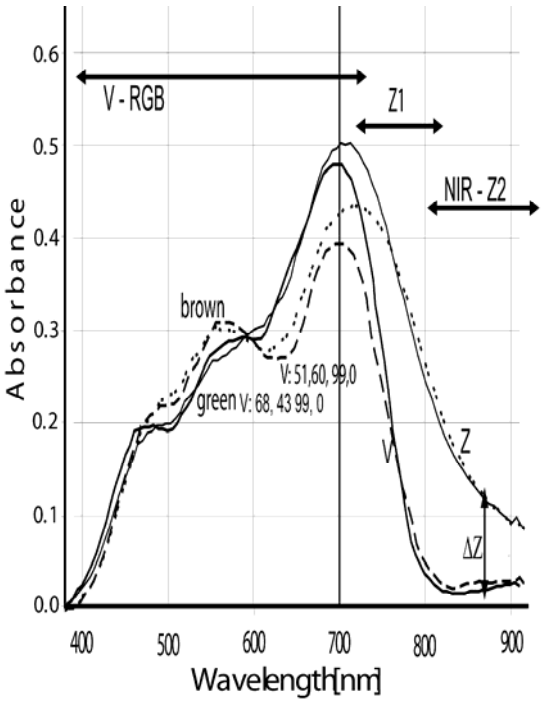

Figure 3. Spectrograms of twin dyes, brown and green color light absorption.

Brown and green colors have very, almost the same Z and ΔZ values. Their delta E values are 3,1 i 3,3, messured from the canvas press. Their spectrograms are the same at the position of 900 nm. This is a targeted mixing of dyes in order to control the image with a Z camera. The graph of light absorption shows a separation of twins of each dye after 700 nm. According to the conventional physics settings, the vision area spreads to 760 nm. This area is visible to our eye, but not as a color, only as an experience of a reddish color. Response of the yellow dye and magenta stops at 600 nm which is an important basis in the procedure of mixing process printing dyes in order to achieve the wanted RGB (red green blue) reproduction.

Cameras for studying IRD – Z areas have been blocked up to 800 nm in order to amplify the experience of separation of infrared Z graphics.

VZ procedure has limitations that are being respected in the process of making a plan of creating a double image, double information. The planned Z image is in the gray range from zero to 40% coverage. The application of textual information (for e.g. names on the dress) are being performed exactly with that highest coverage. All the twin dyes have been experimentally calculated at X0 and X40 values as incoming data to calculate regression equation. The mathematical model (1) of twin dyes gives the dependence of light absorption of all dyes at exactly that value (40%).

(1):

$$C40 = -0.1555 * Y - 0.1536 * M + 1.391 * C - 32.44$$
$$M40 = -0.0134 * Y + 1.383 * M - 0.3232 * C - 32.16$$
$$Y40 = 1.026 * Y + 0.394 * M - 0.341 * C - 36.49$$

All the dyes for V image have been designed in order to perform VZ separation. It has been experimentally confirmed that ZRGB cameras and surveillance cameras in the urban environment of the city "see" well the Z yes with a 40% coverage of the hidden image. Higher coverage of the Z image would reduce the choice range of colorful colors.

3. INFRAREDESIGN® on textile

A hidden image on canvas is being demonstrated in this paper. The double image is being demonstrated with a ZRGB camera as a video recording set to a web space, and as a reproduction print in this printed article. There is an image of a computer graphics of this article's author from the period of "New tendency" [7] on the front side of the dress. The author has today expanded this same visual art work to the area of infrared graphics. They have built into the visual graphics the portraits of this article's authors as a graphics invisible to the naked eye.

Figure 4 computer graphics on the dress

The graphics has been printed on canvas as a digital experiment for the purpose of making the dress. A new fashion design has been opened. The resolution of colors in VZ separation technology has been subordinated to the models of regressive equations and new parameters in raetias published in this work [1]. Double contents on canvas has been shown on figure 4. The first, visual and second in the NIR spectrum.

Digital print has been based on process dyes: Cyan, Magenta, Yellow and Black. Those dyes have their specific properties of light absorption in the visual V and near infrared spectrum measured on Z - 1000 nm. In Figure 5 the connected channels at 580 nm that demonstrate a graphic preparation and the result of scanning the final part in blockades with N – camera [6] are being observed. The presentation has been expanded with a video animation of color change and NIR information in the range from 400 to 1000 nm [8].

Figure 5. Process channels, animation stopped at 580 nm [8]; FigureW5.mp4

A blockade of the color yellow and the beginning of magenta has been performed at the position of 58o nm. The innovative presentation with light blockades provides a study of the proportion of certain process components found in the digital plotter. Above 620 nm not even a red tone can be found. The only remaining color is cyan. Light absorption in NIR - Z2 spectrum is being observed only above 800 nm.

Figure 6. the back side of the black dress

Experiments with individualized dresses carry hidden information. Z reproduction of Zagreb's sights has been performed on black canvas. The black canvas in these experiments does not absorb NIR light. The image has been painted to this canvas with Z dyes as a hidden Z image.

4. Conclusion

Individualization of clothes has been performed by an innovation process of hiding information that is being manifested by using a near infrared camera. Two images are being set to the same place and managed with new mathematical algorithm that has been adapted to ink jet print on canvas. Each color tone has been edited by the process of making V and Z twin dyes, intended for observation in separated sunny areas.

The new way of designing clothes has been referred to the security cameras that surround us. The methods of security print on canvas material as a design to be applied in original clothing making have been expanded.

Reference:

[1] V. Žiljak, K. Pap, I. Žiljak, Cmykir security graphics separation in the infrared area, *Infrared Physics and Technology* Vol.52. No.2-3, ISSN 1350-4495, Elsevier B.V. DOI:10.1016/j.infrared.2009.01.001, p: 62-69, 2009.

[2] M. Friščić, A. Agić, I. Žiljak Stanimirović, Visual and infrared graphic applied through dedicated halftoning for transparent polypropylene packaging, *Tehnički vjesnik 24*, 1 (2017), p 225-230; Original scientific paper, ISSN 1330-3651, ISSN 1848-6339 (Online); DOI: 10.17559/TV-20151231105549

[3] K. Pap, I. Žiljak, J. Žiljak-Vujic, Image Reproduction for Near Infrared Spectrum and the Infraredesign Theory, *Journal of Imaging Science and Technology*, Vol. 54, no. 1, pp. 10502-1-10502-9(9), 2010.

[4] J. Žiljak Vujić, M. Zečević, V. Žiljak, Simulation the colors from nature with twins dyes to camouflage miulitary uniform, *Tekstil*, Vol. 64 No 3-4; p: 89 - 95 en, ISSN 0492-5882, UDK 677.027.4/.5: 677.016.424; 2015

[5] I. Pogarčić, A. Agić, M. Matas, Evaluation of the colorant twins for the neutral gray spectar in infrared graphic procedure, *Tehnički vjesnik / Technical Gazette*; TV-20150303132036 Vol. 23/No. 6

[6] Projectina Docucenter: http://forensictechnology.com/projectina/

[7] Museum of contemporary art, Zagreb: http://www.msu.hr/#/hr/tag/vilko-ziljak/

[8] Animation of infrared design on canvas http://jana.ziljak.hr/FigureW5.mp4