

INFRAREDESIGN® as a Way of Individualizing and Protecting the Textile and High Fashion Design

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ABSTRACT

Textile dyeing today includes the observation and creation of graphics, pictures and drawings for two light spectra: visible and near-infrared. In our work, we have developed systems of twin colorants - colors which are the same in the visible spectrum and different in the NIR region. Measurements of light absorbance at 1000 nm (Z) were introduced, since at this wavelength many cameras recognize the intensity of the reflection of daytime sunlight. The planned dyeing of unique clothing that gives extremely different information in the VIS (V) and NIR (Z) spectrum is proposed. In this work, the embedding of a unique hand drawing for the NIR spectrum into a complex computer graphic for the visible spectrum is demonstrated. Dyeing is done with colorants in conventional inkjet printing by producing the planned graphic form Z in the NIR spectrum, invisible to the naked eye. The final product is individualized in its form and protected; it can be detected and its two different states recognized only with dual ZRGB cameras.

Keywords: textile dyeing, INFRAREDESIGN, hidden image, dye twins.

INTRODUCTION

The work in the paper includes the light region from 400 to 750 nm as the visible zone and from 750 to 1000 nm as Z, a part of the Near InfraRed - NIR spectrum [1]. INFRAREDESIGN® - IRD procedures is developed as the innovation of the duality of a painting, graphic or technical drawing. The V and Z light regions are defined as the combination of V graphics and Z drawings. Different process printing colorants for digital printing in the VZ region were studied [2]. Spectrograms for different values of coverage were determined for them. IRD is most often applied in security graphics, for which algorithms and original programs in PostScript code are published [3, 4]. The mathematical models are the result of the experimental determination of colorant components for "twin colorants" [5]. For a series of twin colorants, the recipes for process colorants with a 40% coverage with the carbon black colorant are determined. The

results are united in regression equations: the dependance of colorant coverage in the NIR spectrum on the values of color parameters in the visual system of colors [6, 7].

Algorithms planned for applying IRD technology on different materials and corresponding printing methods [8, 9, 10] (toner printing, offset printing, screen printing) were developed.

We are surrounded by many different “night cameras” installed in streets [11], public institutions, restaurants, homes and banks, where money detectors are used. Cameras today have multiple functions and are adjusted to register the NIR spectrum in daytime sunlight [12]. These cameras reveal hidden information intentionally or accidentally dyed onto clothes.



Figure 1. Drawing of Korana GF; Insect for hiding in computer graphics

Clothes dyeing with ink-jet algorithm

This paper proposes the introduction of IRD into the design of textile products. Two images are combined according to IRD procedures, algorithms, in order to verify the authenticity of the textile product. Printing was done with the HP5000 inkjet plotter.



Figure 2a, 2b. Two states of the dress, photographed with an RGB (V) camera and as IR reflectography photographed with a Z camera with a filter at 1000 nm [13, 14]

In this paper, image V is a computer graphic, and image Z is a drawing of an insect. Twin colors and colorants were determined for printing with an inkjet plotter. Twin colorants are identical colors with a different response in the NIR spectrum. Pairs of colorants with the value $DE < 3$ were accepted. Eight recipes (Table 1) for twins for process colorants used to reproduce computer graphics within which drawings of insects are embedded are given.

Table 1.

C,M,Y K=0%	% L*a*b	C,M,Y, K=40%	% C,M,Y K=20%	%	
53, 98, 73	25, 56, 9	25, 77, 35	40, 89, 56	1	
70, 46, 99	45, -25, 43	47, 7, 64	60, 29, 83	2	
40, 50, 40	57, 14, 6	15, 22, 1	29, 37, 22	3	
40, 40, 40	62, 5, 7	16, 9, 1	29, 26, 25	4	
40, 80, 40	42, 44, 0	13, 59, 0	27, 71, 22	5	
85, 45, 55	42, -23, -8	67, 7, 18	80, 28, 38	6	
40, 90, 85	35, 50, 31	10, 69, 48	26, 80, 68	7	
70, 85, 40	26, 23, 12	47, 60, 0	60, 74, 22	8	

Two Artists in One Dual Image

Painting dual images has become quotidian since artists realized they do not require special colors or brushes, but only the knowledge that the same colors on the same surface offer

separate views - one seen by the naked eye and one seen by the IR camera. This trend of super-realism is the opposite of everything it is being compared to in art and design history.

Unlike this surrealist game in search of the spontaneous and unexpected, the contemporary dual image can also be the result of two artists' play, but with completely different motives, themes and goals. Their dual image merges into one image separable into two states of perception: one for the naked eye and one for the IR camera. It is unusual, unexpected and intriguing that two objectively real images are never seen at the same time although they are, in this case, reproduced on the same canvas.

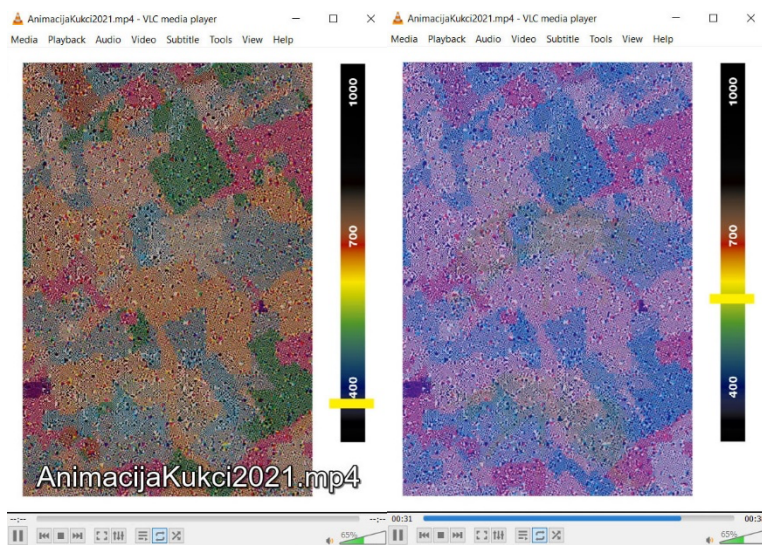


Figure 3a, 3b. Animation stopped at 400 nm and at 540 nm

Changes are observed with the use of filters. Instrument PAG [8] with 24 filters in the range from 360 to 1000 nm is used. The continued blocking of light enables the detection of the color image in different light blockades. The animation is given as a separate record, also given at the address:

<https://www.jana.ziljak.hr/AnimacijaKukci2021.mp4>

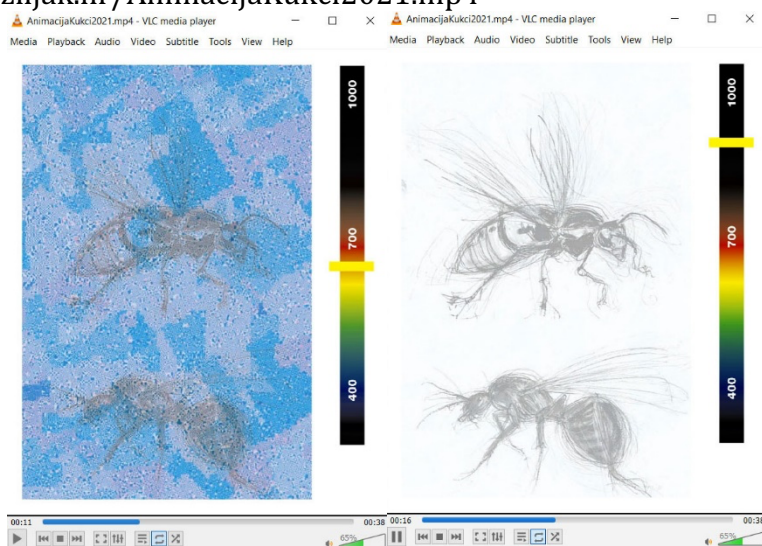


Figure 3c, 3d. Animation stopped at 650 nm and at 850 nm

We follow the exhibition “How to Hide Bugs in a Dress” by two artists of different creative interests and work methods who print one dual image on the same surface, the textile for a future dress. Korana Gjalski Filipović, a photographic designer and textile technology engineer, paints bugs in the style of fashion drawings.

Jana Žiljak, an innovator in the field of IR design, chooses the computer graphic which will “swallow” the bugs, who, although real and existing for the IR camera, no longer exist for the naked eye. The art of design, in this case of textiles, is joined with new findings on colorants. It uses the scientific facts of separate visibility and controls the process of reproduction on textile. When the artists hid bugs on the dress, we got, for now, only the artistic enigma of the dual image, and we confirmed the possibility of achieving separate perceptions different for humans and for robots. What may arise from dresses that joke, that hide graphics and engage mechanics and optics in some future combination of artificial intelligence or robotic difference? No discovery in history was without reason, but was guided by some universal, cosmic intelligence popularly called inspiration, intuition, muse, innovation, idea. And all crazy ideas of visionary artists and scientists later acquired their meaning and purpose.

Two digital records merged into one are observed. This record will enable the reproduction with a dual state for observation with two cameras. The method of the “IR integration” of two images is subordinate to the printing plan for the region from 400 to 1000 nm. The display of the reproduction is identical to the original artwork in two spectra. The animation moves the scale from 400 to 1000 nm, going from the visible to the near-infrared region invisible to our eyes, and vice versa for IR readers.

What does this animated simulation of the movement of light show? First of all, it shows the change of colors and the disintegration of forms that turn into a plain, white background for the drawing (of two insects, two ants) that emerges from the gray color at the same time the other colors disappear and reaches its full form.

Printing with the IRD technology

Printing is done with four process colors: cyan, magenta, yellow and carbon black.

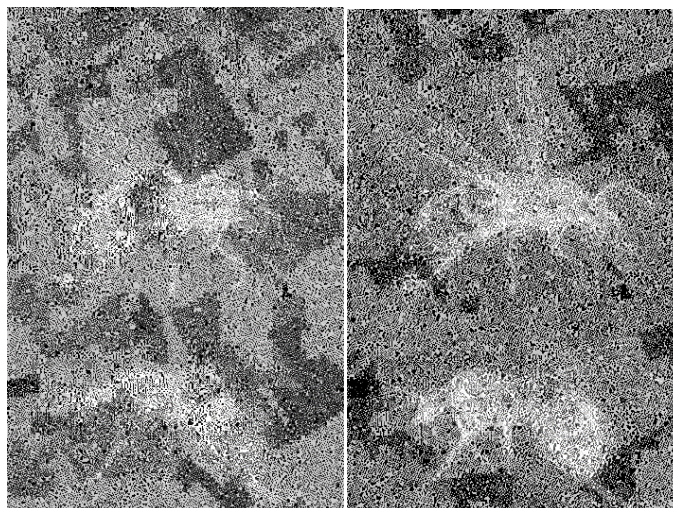


Figure 4a, 4b. Channels C (cyan) and M (magenta)

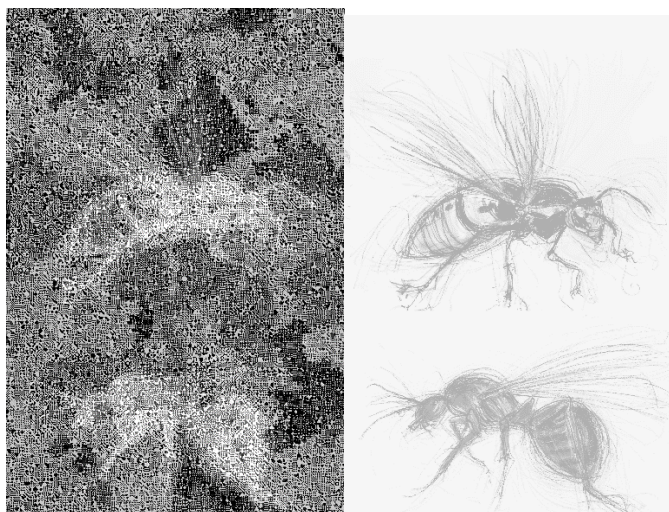


Figure 4c, 4d. Channels Y (yellow) and K (black)

Combining four records C, M, Y and K [10] (in PhotoShop) shows a color image in the visible spectrum. Channel K reduces (Gray Component Replacement, GCR) colorants in every channel. Every channel of process color reduces the color in the visible image. Channel K compensates for all three process components separately. The relations, regression equations, are adjusted for inkjet printing:

$$\begin{aligned} C_{40} &= -0.0513 * Y - 0.0797 * M + 1.1581 * C - 24.89 \\ M_{40} &= -0.0670 * Y + 1.2537 * M - 0.170 * C - 31.66 \\ Y_{40} &= 1.0691 * Y - 0.0296 * M + 0.0165 * C - 41.14 \end{aligned} \quad (1)$$

These equations are offered for running, planning a computer program and checking the GCR replacement of C, M, Y with K. They can be valid for a wide range of colors as practiced in free computer graphics.

The questions are asked: how to achieve reproduction of something that is created from the same thing (same colors of different responses at different frequencies), but is observed differently? The research into these problems has shown that the complete control of the creation and reproduction of dual images is possible. Jana Žiljak has already demonstrated the dual image several times on post stamps, on the textile for military camouflage uniforms and on various other surfaces. Now, in this paper, in the play of the two artists who together create a dual image reproduced on the textile for a dress, new possibilities are opened. In fashion, orders of limited, personalized offers are possible; unlimited possibilities are opened up for combinations that, in simplified terms, fool spy cameras and lead to wrong conclusions.

A word at the end

Are day and night, that visual separation into colors and non-colors, the guiding principle of this privileged spectacle of dual images where the public and intimate, open and secret work together, where the nanometer slides toward forbidden regions, and where artistic casualness and science merge into a play of dual images, without the need for “smart” answers? Whether an indignant viewer of Edward Munch’s *The Scream* hid the text about the madman who painted it in the painting or the author described himself in third person is still discussed. So much mystery surrounds Albrecht Dürer and his numbers in magical crossword puzzles that

produce the number 34 in all directions. There is so much research on artists who always had the need for a certain amount of mysticism and enigma. What will curators say when they discover IR art and IR design as forgotten and rediscovered knowledge? Where will artists conceal their attitudes opposed to the ruling ideology and their protests against a militarized world if robots with IR eyes are their censors? For now, things are better left as they are. Infrared art and infrared design still have the privilege to be mysterious.

For this innovation, the painter drew about ten different insects (Figure 1. and all.). The same computer graphic (the same image in the visible spectrum) hides a different solution (Figure 5). The advantage of digital printing is obvious. Each new print gives an individualized, planned solution with the chosen image of the hidden insect.

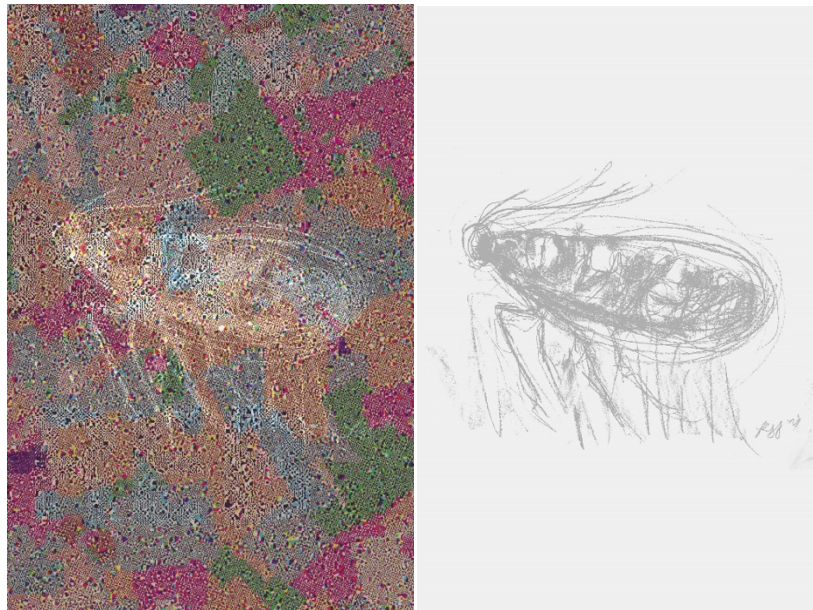


Figure 5a, 5b. (C,M,Y) and (K)

By adding, integrating image 5 a and image 5b in Photoshop, a visual experience equal to the merging of images is obtained: 4 a, b, c, and d These two images (Figures 4 and 5) differ in their view in terms of the NIR camera.

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