

HIDDEN INFORMATION IN VISUAL AND INFRARED SPECTRUM

SKRIVENE INFORMACIJE U VIZUALNOM I INFRACRVENOM SPEKTRU

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Abstract

The paper is about a new method for managing the information, respecting material characteristics in the near infrared light. Common ground has been created with the visual and near infrared component of the sunlight as a new manner of researching, interpreting and managing colours and dyes. Until set theory named INFRAREDESIGN /1/, /2/ the „colour management technology“ dealt only with the perfectionism explanation and interpretation of the relationship colours and dyes for visual feeling. The practice of using colorant matter characteristics is extended in such a way that a colorant is simultaneously designed for visual and infrared area. The discovery of INFRAREDESIGN encourages to make way for many new area of information science applied to painting, prints, military clothing, leather and textile design. Communication is extended to planning a double independent information on the same place as a double picture, i.e. two messages that are dependent on each other in the course of realization, but when trying to make a copy, the message in infrared is lost.

Sažetak

Govori se o novoj metodi upravljanja informacijama respektirajući svojstva materije u bliskom infracrvenom spektru. Stvoreno je zajedništvo vizualnog i bliskog infracrvenog dijela sunčeve svjetlosti kao novi način izučavanja, interpretacije i upravljanja sa bojama i bojilima. Do pojave naše teorije koja nosi naziv INFRAREDESIGN (11), „color management teorija“ se bavila samo s perfekcionizmom obojenja za vizualno doživljavanje boja. Proširuje se praksa iskorištavanja svojstva materije bojila tako da se istovremeno projektira bojilo za taj novi, prošireni prostor upravljanja bojilima i bojama. Otkriće INFRAREDESIGN potiče na brojna nova područja u informacijskim znanostima s primjenom u slikarstvu, tisku, vojnoj odjeći, u dizajnu kože i tekstila. Komunikacija se proširuje na planiranje dvostruke nezavisne informacije na istom mjestu koa npr. dvostruka slika, dvije poruke koje su zavisne u realizaciji, dok se kopiranjem gubi poruka koja je bila u infrared stanju.

INTRODUCTION

IR light spreads from 700 nm to 14000 nm and is divided into several areas. The reflected area is the light coming from an IR source. It is partly absorbed, and the remainder is reflected, i.e. it is reflected from matter. There are two parts that are observed and applied independently. The first area is the near IR from 700 to 1000

nm. The second reflected area is the short IR waves from 1000 to 2400 nm. Strong atmospheric absorption of IR is from 2400 to 3000 nm. Thermal radiation comes from matter, i.e. it is reflected by matter itself. It is divided into two areas. The first is with the name short IR – „SWIR“ (from 3000 to 5000 nm). The second area is the long IR that is marked with

<<LWIR>> (from 8000 up to 14000 nm). The thermal infrared area is very popular and has a wide field of application, especially in medicine.

IRD has been introduced studying of the near infrared area absorption (from 700 to 1000 nm) into visual communications and into the graphic industry. This has enabled us to enter this area in a specific manner with the goal to create invisible and hidden information. The characteristic feature of human eye that it does not see and recognize it in the NIR area have been used for different purposes such as in producing documents, medicine drugs protection, and even in producing masking uniforms for daylight and nighttimes observing. Methods INFRAREDESIGN have been developed and new areas are developed with the names: IRDesign, IRArt, IRUniforma, IRMilitary, IR Informacija and Invisible IR-BARCODE.

INFRARED INFORMATION IN NATURE

Results of invisible graphics, hidden information, double images are equal whether they are at a temperature that is below zero or at 100° C. Until the present moment the near infrared area had not been researched in a manner so as to plan producing double information. Thousands of colorants have been tested; industrial, for artistic purposes, for graphic techniques, and research has been extended to nature by entering into it: the flora, fauna, minerals. It has been determined that the flora does not absorb infrared light wavelengths /3/. That part of nature is „white“ for IR cameras. Natural products such as red wine are white in the NIR. The ink and pigment composition for artificial coloring of fabric material and leather is a secret owned by their producers. The wide range of possibilities of such inks in the IR specter is a basis for a new approach to information management in visual systems.



Figure 1. Flora and fauna in the visual and near infrared spectre.

This is where research begins of nature that carries the information on colorants of plant, animal, mineral and chemically artificial origin. Bumblebee on flower, Figure 1. Light absorption on skin and hairs in the fauna area has a wide range of absorption values in the NIR specter, characteristic for animals only. It is only the beginning of making such measurements, and this has been initiated in our laboratory. This is new information added to the vast fauna world. Chameleons are not hidden in flora environment any more. The IR camera „sees“ an enormous contrast; dark gray on a white background. Research on absorption in the near infrared area of 700 to 1000 nm range /4/, /5/, /6/ has been introduced into visual communication and the graphic industry. It has allowed us to enter this area in a specific manner with the goal to produce invisible and hidden information.

There are two approaches to the study of dual information, based on the theory of IRD: an „active“ one and a „passive“ one. This registering manner, let us call it „the passive manner“ is an essential step in knowing the NIR matter characteristics. As shown in Figure 1. Active hiding of information /7/, /8/ is programmed and planned with such information. The active manner of managing information in the NIR specter is arranging different colorants next to each other, by taking into account their common characteristics. Either they have the same NIR absorption, or they have the same visual shade but different absorption values. Thereby the picture can be hidden in two ways: by hiding it in the visual specter and hiding it in the infrared spectre /9/, /10/, /11/.

NUMERICAL VALUE Z IN THE INFRARED SPECTER

Due to reasons linked with reciprocal communication, and with programming of an enormous number of colorants on materials and determining absorption characteristics of the near infrared specter, a numerical variable named Z that describes the power of absorption of NIR light at 1000 nanometers /12/ has been introduced.



Figure 2. ZRGB cameras with a portrait image: the visual and near infrared specter (11)

There is a new proposal in Figure 2 for making portraits on documents. A dual situation with an en-face and profile image was resolved by one single printing process with CMYKIR separation/13/.

The two images create an independent relationship; i.e. they protect one another. After scanning, the second image disappears. The information is gone. Contemporary scanners are adjusted for the visual specter only.

Also, a „double camera“ was designed that registers two states of matter if illuminated with sunlight. The first camera shows the RGB color as seen by our eye. The second camera shows the Z information on the infrared light component absorption from the surrounding area /14/.

The ZRGB camera is used in two cases. As passive monitoring VS and NIR state of nature. Secondly, as the determination of mixing colors for an active step in the creation of IRD information. If the double ZRGB camera were used in making forgeries in order to detect duplicate images, and two different records were obtained, a new problem would arise: how to join two images into a single print.



Figure 3. Double informations printed on ZRGB box for visual light / NIR spectrum

Design the ZRGB box used the method of stochastic design has been developed. Information on colorants is produced with the help of pseudo-random number sequence generating. All parameters of the congruent method are individualized. This improves protection of information hidden in the multicolor design on medicine wrapping material. Portraits of Van Gogh and Leonardo da Vinci, Figure 3, have been merged with CMYKIR multicolore separation technology /15/.

MASKING UNIFORM IN INFRARED

If the flora is white in near infrared light, then a masking uniform can also be white in the same specter. The contribution of INFREDESIGN technology is in introducing a mark on the uniform that is not visible in daylight and is hidden with the goal to be recognizable in NIR light /16/.



Figure 4. Camouflage uniform in nature VS (400 – 700 nm) / NIR (1000 nm)



Figure 5. Masking uniform with an emblem in visual (400 – 700 nm) and NIR spectrum

The procedures have been set to resolve the manners of mixing inks for masking uniforms; inks with multiple visibility characteristics in the NIR/VS specter, Figure 4. The same color shade falls into new mixing recipes in order to achieve IRD effect results. Ink with invisible information for the VS is applied on fabric to be further recognized in set target wavelengths, Figure 5.

ART PAINTINGS WITH A DUAL STATE OF INFORMATION

Characteristics of individual matter are considered, i.e. individual relation towards the NIR: some colorants absorb NIR to a great extent, and some do not absorb at all even though colorants of the same shade /17/ had gone through observation. For instance, two pairs of colorants on a piece of cloth were observed and they appeared red /18/. One piece of cloth will fully absorb the NIR light, and with the other the result will be null. The first one will be interpreted by the camera as black because nothing had been registered by it. The second red cloth will be interpreted by the Z camera as white

Table 1. Information on the absorption of light in the visible and infrared spectrum

Acrylic, Royal / Talens Artistic colors	Visual spectrum (400 – 700 nm)		NIR 1000 Z (%)	on nm,	Gray – Z (%)
	R, G, B (0 - 2 ⁸)	Gray (%)			
504, ultramarine	0, 23, 140	85	80		5
568, permanent blue violet	10, 0, 110	91	23		68
409, burnt umber	110, 40, 0	85	84		1
270, azo yellow deep	225, 130, 0	42	25		17
570, phthalo blue	0, 10, 70	95	65		30
396, naphthol red medium	230, 4, 0	67	22		45
411, burnt sienna	160, 20, 0	75	60		15
267, azo yellow lemon	230, 230, 0	24	23		1
227, yellow ochre	175, 120, 0	56	45		11
619, permanent green deep	0, 40, 25	92	90		2
617, yellowish green	80, 220, 0	38	42		-4
572, primary cyan	0, 50, 170	82	52		30

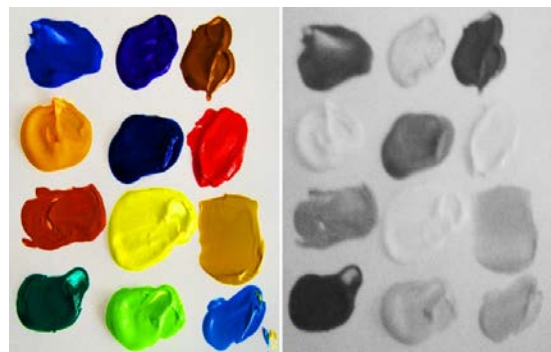


Figure 7. Colors for Artists in the visual and infrared spectrum

because all the IR light had reflected and "blinded" the Z camera's sensors.



Figure 6. Oil and acrylic colorants for artistic paintings VS / NIR

Contemporary colorants do not have information on their characteristics in the IR specter /19/, Figure 6. The overall art of painting today falling into the category of beautiful arts is subject to the visual experience of the finished painting. Additionally, each painting colorant was marked with the value named Z that guides the painter as to the colorant's response in infrared light.

There is no analytical or technological dependency between the value Z with any of the variables red, green, blue or gray, which describe the information about light absorption in the visual system (from data in Table 1.). Hence arises the claim that the size of Z is defined only as property of matter, Figure 7. Z extends the description of the flora, fauna and minerals by determining their properties under infrared light. Size of Z is associated with matter, and it will have a huge application in the visual world on the way of creating a double image, invisible

information, hidden graphics. By knowing this numeric value, a way of making up new materials with an aimed mission was opened: invisible twin information in the visual specter, and visible in the near infrared specter. And vice versa: Unrecognizable information in the infrared, and discernible double information in the visual specter.

The artist begins creating the painting for its two visual states. The painter can mix the desired shade, for instance: a shade of green, in an unlimited number of ways.

However, respecting the the target to incorporate two images into this painting game, the painter mixes two greens. The first green does not have absorbing characteristics to respond in the infrared specter, whereas the second green has a strong response in the NIR. There is no correlation between the colors, their description in the visual specter, or the level of light absorption in NIR. The future of the art of painting with Z colorants will open a new manner of expression. The exterior picture and the inside picture named as the artist's intimate world are fully independent of each other.

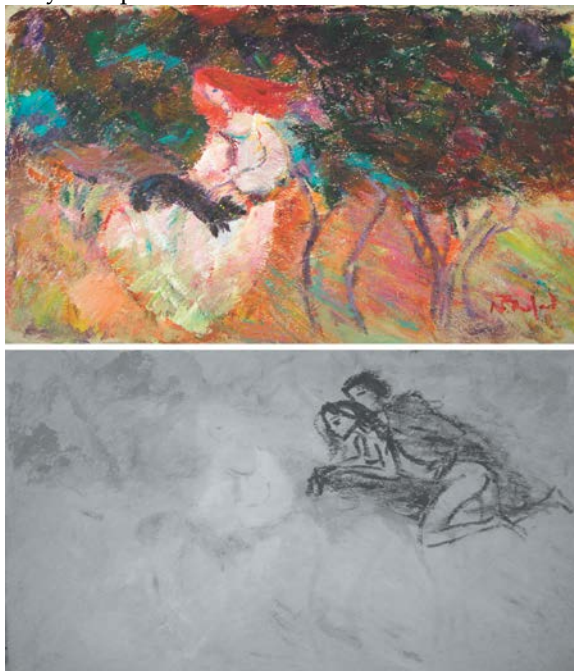


Figure 8. IR Art Double painting acrylic on canvas, the visual and infrared spectrum

There are two fully independent contents in the same canvas. Simultaneous planning of a double image state is carried out in various art painting techniques, Figure 8. Art pictures was

on water-color, acrylic, tempera on paper, and oil on canvas. There is a big collection of such works of art on constant exhibition at the Sv Ivan Zelina art gallery. The pictures have been exhibited all around the world presenting the completely new manner of painting and a new way of artistic expression /20/.

INVISIBLE BAR CODES



Figure 9. The invisible QR code, legible with an IR camera

Codes, bar-codes and many other codes are legible with readers and therefore codes in millions of different colors have been created. A multicolor background has been introduced, as well as multicolor bar-shaped or otherwise shaped graphic elements. The paper describes the solution for a bar-code that is invisible to our eyes, Figure 9. It is seen by the instrument, i.e. the infrared camera enabling information transfer into the computer. This manner of information encoding has not been researched at all. It extends graphic design significantly and the information system for hiding information. The same bar code is planned to be positioned on the wrapping material in some ten places. Bar code readers with the possibility of recognizing in the infrared will find the piece of information carried by the bar code.

DESIGN AND WRAPPING MATERIAL SECURITY

By designing double information for the visual and infrared specter, brand new possibilities are at our disposal in the approach to wrapping material design and security. A new advanced method has been discovered for marking and protection of designer products. There is possibility now to add new information for security

purposes, without changing the visual design at all. Consumers are surrounded with intriguing, perfectly designed and produced products targeted to achieve the best possible communication with potential markets, as well as to be placed there. The possibility of creating new innovative wrapping material may also provide numerous advantages for the consumers, as well as the producers. A product designed in this manner carries two different pieces of information. An idea can be developed on two different levels – the visible/invisible and the visible. The communication system thus improves; a new alternative level is achieved for sending essential messages to the recipient. This can be observed through the communication channel as exchanging matter that as such needs to be prepared in a form that has certain characteristics. Secured information gives a feeling of security and extends the consumer's trust. Application is possible on different types of material: leather, cardboard, silk, for instance; targeted at advanced visual communication. The listed possibilities are a contribution to the designer trade and its creative followers. It is important to stress that both designs and both pieces of information are positioned on the same surface area, and that they are both produced at the cost of only one picture.

When making the content design, two pieces of information can be linked to each other or they can be completely different. There are no creativity limitations in respect to the relationship between two messages. This manner of design makes way for catching the recipient's and message seeker's attention in respect to the said contents or product at a much higher level. On basis of numerous tests and actual production the functionality and application quality of double design on wrapping material has been proved.

With the use of design in the infrared specter targeted at securing the product against potential counterfeiting, it has been made possible to have the product remain the same in respect to visual design; to have it keep its information character. Additional new information has been added, the information that is impossible to copy. Besides improving communication possibilities, the advantage of infrared design dis-

covery is in its being applied in the production process. Thereby it becomes a joint part of the wrapping material production and it does not influence the product's cost.

Products incorporating secure information as their integral part from the very beginning of production will have an advantage in design. By preparing such a product for printing actually two images have been designed. Through the design the relationship between the two images and the quantity of information that each individual image will carry have to be set. Users will be secure in getting the original product, and thereby all the advantages and quality that the product, i.e. the label or brand mean to them. An additional platform has been created for sending key importance messages and ideas, and thereby new possibilities of managing the label or brand.

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