# Digital print of documents containing the infrared protection of information

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**Abstract:** *Digital print enables the control of light absorption in the visual and close InfraRed spectrum by developing a system of dual information. The IRZ method of transformation is being introduced for turning **R**ed **G**reen **B**lue colours into **C**yan, **M**agenta, **Y**ellow and Blac**K** dyes with **I**NF**R**STR**D**ESIGN method for printers and devices – **C**omputer **T**o **P**late – in graphic technology. Consequently, a widened graphic technology based on algorithms and programme solutions for the creation of alterative invisible information is being introduced into information science. This paper demonstrates IRD solution which algorithm is contained in the printer driver. Since input data include at least two independent pictures, this enables a new steganography method of hiding the information. The second, invisible information can be a text, picture or ideogram inserted into the visual information. The term "Z information" is being defined as information/graphic documented on print, invisible to the naked eye, available through an infrared camera in a close infrared spectrum of 1000 nm.*

**Keywords**: IRD information, infrared graphics, Z information, safe print

# 1. Introduction

INFRAREDESIGN is a new method in the analysis and creation of dual, invisible information (Žiljak, Pap & Žiljak, 2009). Science developed observation methods for flora and fauna in V and Z spectrum, followed by processes for creation of IRD hidden information containing algorithms for digital print (Vujić, Zečević & Žiljak, 2009). The substance has the ability to absorb Z wave length (Žiljak et al, 2012) so to enable a procedure for mathematical description of its attributes in graphic reproduction containing the visual and infrared spectrum. Information developed through IRZ procedure cannot be scanned since they contain two independent pictures. This process requires at least two cameras containing different filters, the first one in the domain of visible and the second in the domain of close infrared spectrum (Žiljak, Pap & Žiljak, 2012). Conducted experiments have been based upon selections and cameras that select at least ten points (Projectina (man), 2012). Forensic instruments enable the observation of continuous phases of safety graphics up to the creation of digital information such as video and film by joining a line of pictures on the substance's attributes within the UV, V and Z absorption area. Such information is gathered from flora's reproduction that simulates the same attributes, though as print, either on paper, skin, polymer materials or in some other substance (Vujić-Žiljak et al., 2013).

Translating RGB into CMY initiates a partial substitution of CMY with some fourth colour as "reduce" element. Practice recognizes cascade change of black colour known as GCR (Gray component reduction), UCR (under color removal), UCA (under color addition) etc. Within such replacements a visual experience of RGB picture remains the same. For the same purpose (remaining RGB picture), CMYKIR (Žiljak, Pap & Žiljak, 2009) method has been introduced together with the alignment to CMYIF (Morić-Kolarić et al., 2015). Z separation enables the introduction of a special picture within channel K (Žiljak at al, 2012). This procedure enables the existence of two pictures within the same area. Since colours can be recognized beyond the naked eye, within infrared and ultraviolet spectrums, it was necessary to introduce an absorption control of sunlight for both spectrums. The Z separation method requires an infrared camera for observing an additional hidden picture. The picture is intentionally planned, designed for a close infrared spectrum while simultaneously being invisible in V (visible) spectrum. ZUV separation is the procedure of replacing CMY with dye that in its own specific way absorbs ultraviolet light and IR light in the position of Z wave length. "Ultraviolet dyes" are usually applied in documents and banknotes in several different shapes. Under UV lights the invisible pictures are obtained in V spectrum, while visible pictures are being transformed into other colours by applying the dual response of UV dye.

## 2. Analogue print on banknotes

Colours on banknotes contain much more information than visible by the naked eye. Though Croatian banknotes have been prepared as computer graphics in vector form, they cannot be separated by IRZ method or reproduced by digital print. Each colour has its own shade, brightness and other graphic L*a*b parameters. the enlarged area of colours and dyes provides information for the infrared and ultraviolet spectrum. There is no graphic preparation or print that would simultaneously display all shades of colours on banknotes. There is no way of making it happen. Colours from the enlarged spectrum are planned while all information is recognized only through selective barrier scanning since colours on banknotes are separated for ultraviolet, visible and infrared areas.

The composition of analogue colours and spot colours on banknotes are never published. IR dyes on the present world banknotes do not hide any other graphic or information. They do not apply IRD method (Pap, Žiljak & Žiljak-Vujić, 2015). In close range they comprise united graphics but their transition and contact are not specific in identifying the shades of colours. In the continuance of this paper (Chapter 3), the effect of dual colours is performed in CMYKIR (Žiljak, Pap & Žiljak, 2009) digital specification.

Figure 1.

UV 254 nm Banknote 10 Kuna    UV Banknote 360 nm    Visual Banknote (400 – 700 nm)

Figure 2:

570 nm Banknote 10 Kn    715 nm Banknote  Z - 1000 nm    Banknote 10 Kuna

The displayed banknotes envisage different information when observed in light barriers of 254, 365, 400-700, 570, 715 and 1000 nm. The area stretches from ultraviolet, through visible up to the close infrared spectrum. Yellow becomes invisible in 570 nm. The red channel disappears in 715 nm. In 1,000 nm range only infrared colours remain visible in all spectrums. Croatian banknotes have a specific Vignette of dual colours on a nominal value. Number 10 (ten) is designed in a leaning Vignette. The first part is printed with IR twin, while the second part is printed in a colour that does not absorb infrared light. That part of nominal is lost in the NIR spectrum.

The banknote contains several pictures that respond only to a certain light frequency. A video presentation has been used to enable a simultaneous observation of banknotes of different shapes. Some information become visible, then disappear replaced by new ones. A display of such changeable conditions is given in "flash player" system while recordings can be seen on the website: www.jana.ziljak.hr/10knDobrila.mp4 (Žiljak-Vujić, 2015). Blockage scanning enables insight into forensic level of information upon combining spot colours on banknotes.

## 3. Digital Vignettes as vector graphics

For colour to be realised on a digital four-colour printer as a dual dye, it is necessary to describe dye in numerical values. PostScript language is used levelling vector graphics in two shapes. Every beginning is submissive to the general theory of process separations, but after the first test, iterative print makes basis for specifying qualitative twins. The biggest advantage of digital print is individualisation of reproduction. Each new page can be specially marked by managing the algorithm which either generates individualized data or extracts it from digital information base. A typical protective graphics is designed as Vignette or line shapes. An example with hidden information "UNIVERSITY OF JURAJ DOBRILA IN PULA" is illustrated in visible and infrared condition. Continuous changes can be seen as video at the address: www.jana.ziljak.hr/VinjetaValDobrila.mp4

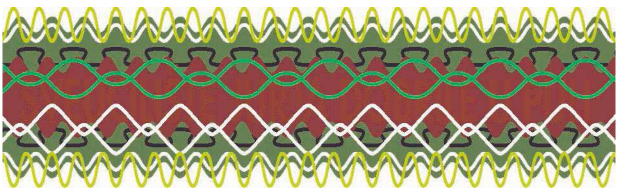

Figure 3. Vignette in vector shape observed within the visible spectrum (400-700 nm)


Figure 4. Vignette scanned in Z shape within 1,000 nm radius

After printing, rehearsing or processing, each colour is analysed through graphic ΔE value of colour similarity in the visual spectrum and through a spectrogram in the visual and infrared area. Dyes have quite similar spectrograms in a visible spectrum but different in Z spectrum.

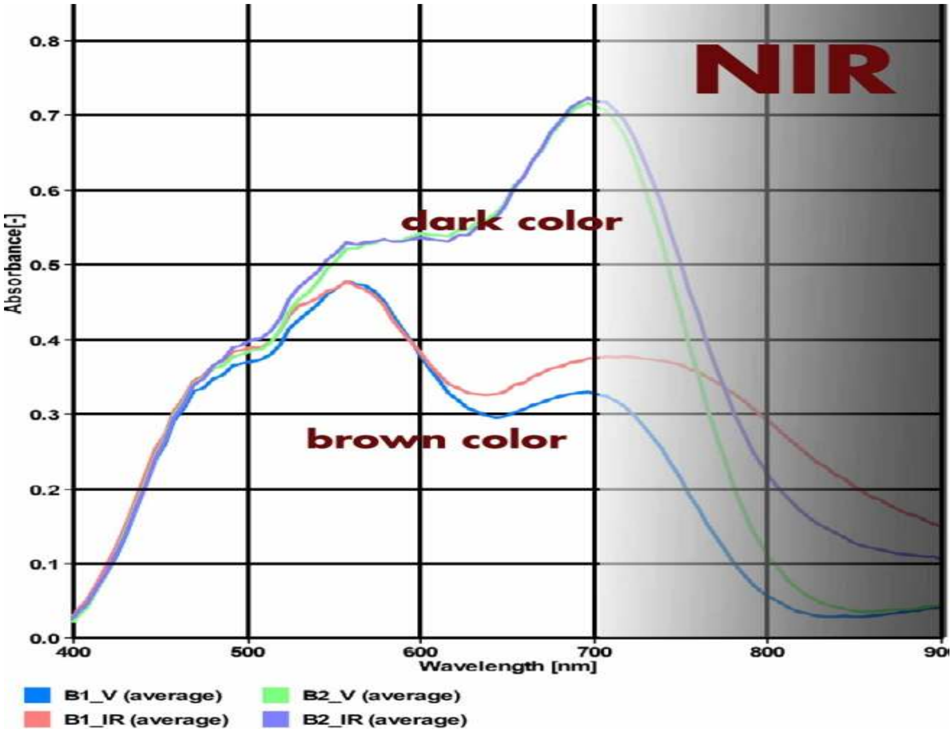


Figure 5. Spectrograms and two-colour twins

| Color of twins | X0 (C, M, Y, K) % | Z (C,M,Y,K) % |
|---|---|---|
| brown | 48, 86, 77, 0 | 5, 72, 60, 40 |
| dark | 85, 85, 85, 0 | 82, 80, 75, 20 |

Table 1: Numerical values for dyes' twins in the system of processing colours for digital print

All twins in X0 form are connected in the same point of absorption of Z wave length.

The dark twin has a twice smaller Z component so its point in Z condition is lower than for Z brown twins.

When two or more dyes with different contents provide equal spectrum curves in a visual spectrum, then human eyes do not differentiate those dyes. If these dyes have different reproductions, different characteristics of light absorption in infrared spectrum, IR cameras will differentiate them thus enabling the creation of Z information.

Twins of dyes are developed to enable the hiding of information through digital procedures. Spectrograms of light absorption in visual (V) and close infrared spectrum (NIR) have been made for this purpose. Instruments and tools of "Projectina" (Projectina (man), 2012) device have been used which enables the analysis of light absorption in dyes. Similarities have been defined for two extreme twins and chosen shades of colours. Iterations in print and spectroscopy have given a qualitative identification of dyes in V spectrum and the wanted difference in NIR (close infrared) spectrum. The authors suggest the correction procedure for dyes' content on the process components C (Cyan), M (Magenta) and Y (Yellow).

The area between 500 and 700 nm represents a huge challenge for equalizing twins spectrums. Magenta and cyan are strongly interconnected, covered and mixed in this area. Depending on the dye producer, magenta and cyan have up to two maximums. It is not possible to achieve a complete equalisation of twins within the visible spectrum. An optimal condition can be accepted when $\Delta E$ reaches a value of less than three. Graphic designers agree to compromise in the final equalisation of twins. The connectivity of twins in print is improved in several ways: hiding is improved by different procedures of individual rasterization, mosaic structures and stochastic influence in the structure of the dyes components.

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**The limit area** between 700 and 800 nm displays the mode of transition from the visual spectrum to Z shape for dyes twins. It is recommendable to achieve the peak of spectral curves in 700 nm height. The event $\Delta Z$ with Z camera represents the difference between the Z curve and V curve.

The spectrogram displays equalisation in the visual part, and a difference in the close infrared part. After 700 nm, twins' curves are separated thus achieving a wanted difference in 900 nm. In 900 nm point a Z camera will recognize a hidden Z picture.

The analysis of **NIR** starts with analysing the characteristics of dyes used in the creation of pictures for a Z camera. Within this narrow segment of NIR, many materials' specificities have been defined, specificities that cannot be discovered outside the IR area. The segment of interest has been isolated, dyes have been developed and a new information structure has been constructed. Taking a step back through the range of 700 to 800 nm, a connection has been made to the visual spectrum using the new term "twins of colours and dyes". This leads to the development of a new theoretical, spectroscopic activity that has a purpose. The mere measuring in that area that represents a research without meaning becomes purposeful. The purpose is to achieve Z twins as a family of substance with specific common characteristics.

Hiding and revealing information can be done only if twins of dyes are used. These are dyes with identical experience of colour in a visual spectrum. Twins have an equal shade of colour, equal in the visual spectrum. They are different by characteristics of infrared spectrum's absorption. A twin with a strong reproduction in the infrared spectrum enables designers to make an invisible picture. This picture is invisible to watch by the naked eye, but can be recognized when observed by infrared glasses. Twins that mutually hide their information are located within the same area, so they have to be “perfect” in the shade of colour. The creation of twins represents a huge mission for dyes’ producers, printing houses and graphic designers in general.

## 4. InfrareDESIGN in printer drivers

The information is inserted in the printer driver. Algorithms and computer program solutions have been developed for managing dyes in printers thus causing dual pictures. The information comprises a visible and invisible picture and dual pictures in the same area. One picture is manifested only in the visual spectrum while the hidden picture is observed with a Z camera. The idea was developed on IRD procedure which reproduction cannot be copied so a document was provided with a new form of protection. A copy would be identical only for the visible, RGB spectrum of colours. Since INFRAREDDESIGN program is memorised by a printer driver, each initiation of print causes an addendum to IRD graphics regardless the program that initiated printing.

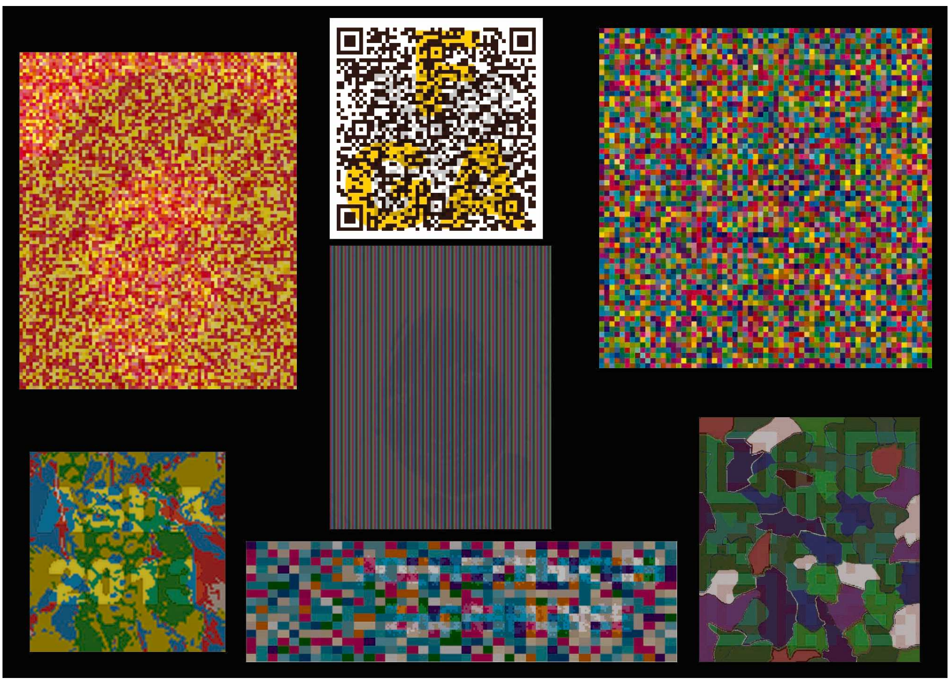

Figure 6. IRD solution for print box with dual hidden information

The visual and infrared conditions of graphics on picture 6 are derived by continuous scanning and can be found on the address www.jana.ziljak.hr/printerDriveri.swf as animation. In the upper middle side QR a code can be seen which in IR condition contains a completely different independent code. This other hidden code can be read in the second phase with two detectors (Figure 7). A hidden camouflaged code can be found on the other example located in the bottom line on the right.

The performance of "printer driver" graphics is generated by general regression equation that covers a whole spectrum of dyes since visual information is designed in "free style of colouring". The translation from RGB to CMYKIR depends on the substance on which the dye is being deposited and on the characteristics of dyes in their absorption of sunlight. Several mathematic models have been provided by the article (Žiljak et al, 2015) which describes the application if IRED technology for different purposes within the same project of designing a "1000 colours" stamp. In general, some authors of CMYKIR separation insist on individual twins of dyes (Chao, Calyn & Shujie, 2013). Such solutions have been explained in Chapter 3 for specified shades of colours and vector graphics with thin lines in the final performance.

The first large 'print box' application was used at Polytechnic of Zagreb. All documents printed in this institution are marked with a dual picture for the purpose of their protection against copying. Similar solutions are applied for diplomas, confirmations and other printed information.

Figure 7. Reading a hidden code with double cameras

Reading a hidden code is done by a mobile phone, while ZRGB camera is situated between the print and the mobile phone that also filters information. Copy devices do not register such IRD graphics.

## 5. CONCLUSION

With practice it is possible to add multiple data printed on the same media. It manages dyes in modalities which enable tagging of documents with invisible signs. Gilt and documents become unique, exceptional, personal and individually marked.

IRD is based on the idea of hiding information by graphical methods. This process makes a dual form of graphics, pictures and texts. It is a new sort of camouflage. It is a new tagging mode in textile, leather and general graphic industry which uses digital preparation and digital print. Information is being recognised by new modalities that use dyes on different materials, with different dyes and different technologies of colouring. Programs for INFRAREDESIGN information are implemented in the printer driver as a new option in the theory and practice of IRD procedure. Documents have been individualised due to printing by digital printers, and due to the characteristics of the dyes in the spectrum whicht have been enlarged to close infrared Z wave length. This approach to the protection of information will certainly be relevant in education regardless the level of education.

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