Achromatic Procedures at Standard Autotypic Printing Processes and in Secured Double Images CMYKIR Technology

Akromatski postupci kod standardne grafičke autotipijaske reprodukcije, te kod metode zaštićene slike CMYKIR tehnologije

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Abstract

Modern graphic arts image reproduction procedure is based on subtractive synthesis inks and appropriate screening system. When fourth color, K color is added to the printing procedure, four color printing autotypic system is established. When autotypic procedures were associated to colorimetric models, meaningful surrounding for defined reproduction is achieved. Various reasons for reproduction enhancement were stated, involving achromatic reduction, meaning substituting some appropriate content of chromatic inks with black. CMYKIR technology starts with CMY image, and a K-NIR image that will be hidden. Absorption properties of carbon ink in black printer in NIR domain instrumentally allows secondary image to be visualized and observed. A brief library of terms used in CMYKIR procedure is enclosed.

Keywords: graphic arts reproduction, autotypic procedure, CMYKIR technology, achromatic reduction, secondary hidden image

Moderna grafička reprodukcija bazirana je na subtraktivnoj sintezi boja te odgovarajem postupkom rastriranja. Kada se četvrta, crna boja doda tiskarskom postupku, postiže se četverobojna autotipijska grafička reprodukcija. Kada se autotipijskom načinu pridruže kolorimetrijski modeli, postiglo se značajno reprodukcijsko okruženje. Niz procedura za poboljšanje reprodukcije se postavljeni, uključujući akromatske postupke koji podrazumijevaju zamjenu odgovarajueg dijela kromatskih boja crnom. CMYKIR tehnologija počinje sa CMY slikom ali i K-NIR slikom koja će biti sakrivena. Absorpcijska svojstva carbon crne u crnoj tiskarskoj formi u NIR području dozvoljavaju instrumentalni pristup te vizualizaciju kao i promatranje sekundarne slike. Daje se kratak opis pojmova iz CMYKIR procedure.

Ključne riječi: grafička reprodukcija, autotipijski postupci, CMYKIR tehnologija, akromatska zamjena, sekundarna sakrivena slika

Common considerations

Graphic arts reproduction is present in Europe from appliance of Gutenberg movable types and printing press, although similar principles were known at the far east cultures considerable earlier. Very soon, not only ministerial and theological items, but scientific, literary, poetic and other titles were published, and become affordable to broad group of consumers. In passage of time, need to attach an image to printed text arise, and this was obtained in various ways. All such procedures were time consuming and manual work demanding. Broadening of common knowledge, advance of science, materials, and other relevant cognitions, now for standard printing procedures we practice four color autotypic process. Basically colors are subtractive. However other colors can be implemented, color system can be broadened, various substrates besides paper can be used, what presumes more complex printing procedure. We must accent that practically in most situations this printing environment connotes image, graphic, drawing or other reproduction in visual area.

Key color at standard reproduction

At the beginning of contemporaneous reproduction film and graphic reproduction according to materials used were close, including color combinations, practicing additive and subtractive color mixing. Utilization of screening systems and implementing fourth color, black, made the graphic reproduction procedure stable and very wide applicable (1). We can treat black ink or printer as primary, as most of printed products were monochrome. Autotipyc procedure introduced screening process, that offered intensity tuning-reflection modulation between plain paper meaning zero coverage, and 100 percent coverage as solid tone (2).

At color printing three color separation offered cyan, magenta and yellow printers. To enhance printed image quality, additional separation for black color procedure was developed. Fig. 1a, 1b. Black printer, as other printers, must have defined reproduction curve-trendline and tone distribution, Fig 1a. This expansion by black increased contrast, improved detail drawing, stabilizes neutral parts and enhances some other graphic arts functioning, today included in ICC and CIE recommendations. Note, that black channel or black printer mainly is B/W or achromatic image of the multicolor original. Especially interesting is achromatic replacement that allows us to change a portion of colored inks with black, that can't be performed in any primary image position. At the same time this procedure allows us to achieve a variety of CMY+K inks combinations producing the same colored sensation.

Fig. 1a: three color reproduction (CMY)

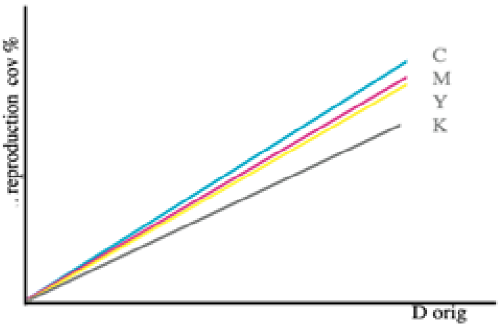

Fig.1b: four color reproduction curves (CMY+K), schematic

Achromatic procedures at standard graphic arts procedures

We must emphasize that standard graphic arts four color achromatic procedures, usually denoted as UCR, CCR, PCR, fig. 2, or similar do not match resigned CMYKIR principles and the interchange approach (3). Standard procedure replaces or changes some adequate part of CMY coverages with (carbon) black. According to most image correction and manipulation applications that achromatic change is stepwise, so that application procedure is not applicable to our CMYKIR separation, as it produces various K coverage amounts from one image position to another. In such stage secondary image would be unequal und deficient. All the same what achromatic definition is used (UCR or CCR) standard program module changes where possible a part of CMY setting in a “low-middle or high” manner with black (4), so black amount, coverage, steadily changes, Fig **2**, displaying maximum possible rate.

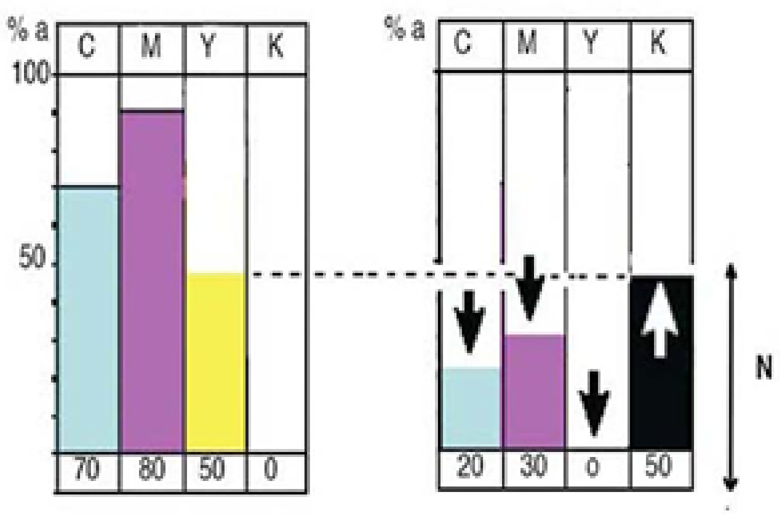

Fig. 2: changing a part of CMY amount with black, according maximum possible rate,

Not only stepwise interchange distribution, but the way how program aided achromatic function module manages this functions is not adoptable, so we developed our purposes designed black interchange module.
According to presented situation amount of interchanged K amount is not immanent. It depends on module setting “low-middle-high” rate, but also on CMY content of any image fragment. That situation also influences the secondary image K content, that could be alterable from image fragment to fragment. Example is given on fig 3a. (CMY image), and magnified sections with “low” (4a), “middle” (4b), and “high” (3c) achromatic (CCR) replacement according to program application (CS).

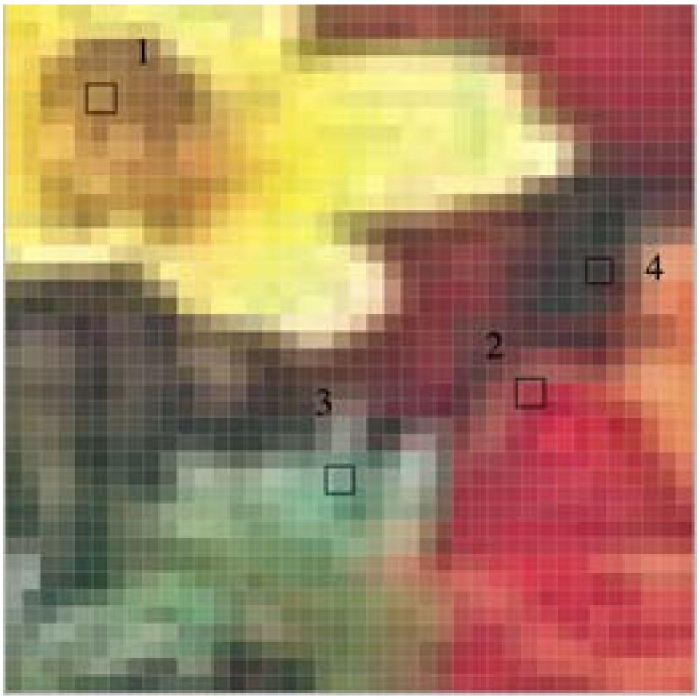

Fig. 3: detail of the CMY image (1a) with four selected points as pixel count defined, where coverages in different reduction rates are inspected

It is understandable that application definition ”none” meaning grey replacement will produce no selection in black channel. Here we give example for observed image how different reduction rates (low-middle-high) will change black channel content (coverage). Theoretically, overall multicolor visual experience should not change.

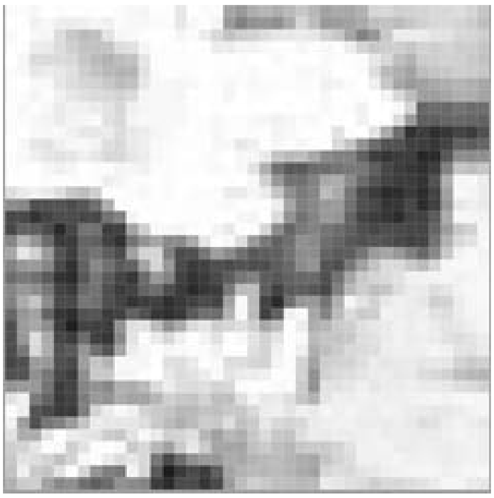

Fig. 4a: black channel setting “low”

Fig. 4b: black channel setting “mid”

For better understanding we gave a possible numerical form of these four observed positions (table 1) on the image indicated as “colors”, and are selected and described as coverages, as indicating values. Their positions are defined in pixel count of the basic image, and described in their possible related coverages, and belonging changes in decreasing CMY versus increasing K, in each reduction rate position are assigned.

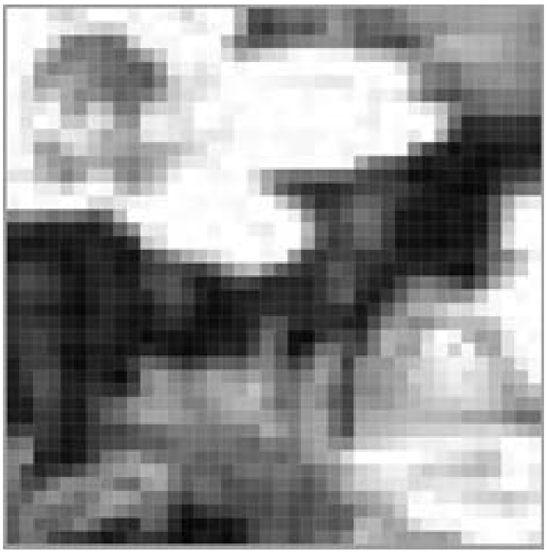

Fig. 4c: black channel setting “high” reduction rate

Table 1: coverages of primary colors changes and K transition by alteration application achromatic reduction rate for perceived colors

Position/color Pixel count Coverages (%)	**1** X 6 , Y 6 Yellow-brown C, M, Y, K	**2** X 31, Y 23 red C M Y K	**3** X 20, Y 28 Green C M Y K	**4** X 35, Y16 Dark brown/grey C M Y K
non	27, 54, 87, 0	24, 98, 81, 0	66, 31, 62, 0	73, 93, 98, 0
light	22, 53, 94 , 8	19, 97, 95, 11	67, 27, 60, 7	53, 78, 88, 61
mid	18, 51, 95, 9	15, 95, 97, 12	62, 19, 61, 17	44, 65, 77, 68
max	0, 40, 90, 30	0, 91, 88, 29	45, 0, 52, 40	0, 26, 30, 83

This table shows practical presumed data from separating application CS module for the observed image, that assumes the output situation.
If no reduction rate is applied, there is no black printer content, and in such condition we can apply CMYKIR separation principles to perform a secondary or hidden image. In the presented table drift of the reduction rate changes can be observed, but the trend indicates that our developed regression analysis with recalculating and correcting the reduction renderings and color values is meaningful to get necessary quality corrected information for obtaining the double image.

Our model of CMYKIR reproduction configures the secondary image first time in Croatia

As stated, our CMYKIR reproduction module starts with CMY image configuration, whereas black channel is still empty. If we let standard black channel, it would contain achromatic image of the original, and would be unsuitable for secondary

image. Secondary image should be independent from primary (multicolor) image, and appears instrumentally due to spectral (absorption/reflection) inks properties in visual and particularly NIR spectrum part (5). Specifications of some colors outside visual part are known, but never used as a secondary image carrier. Whatever primary image is open air one or generated, on secondary image positions twin colors (twins) have to be established. Twin colors in visual part have to work out the same (visual) experience, but in expanded, NIR spectrum part due to (carbon) black absorption they are instrumentally visible, and perform secondary image (6).
For purposes of CMYKIR technology we built special separation module (12). Visualization is achieved with customized dual camera, where we made arrangement that camera for visual part has blocked NIR domain Fig. 3, according to UQG optics.com/filters, and NIR camera has blocked visual domain with NIR filter that covers to us interesting part approximately 1000 nm, Fig. 4, according to Hoyaoptics.com/filters. Other filters from that series we can use for blockade scanning for several wavelengths in extended and expanded NIR domain.
As most of common camera sensitivity covers the range up to 1200 nm, such filter and sensitivity arrangements are acceptable for our system of double camera and performing visual and NIR images performing simultaneously.

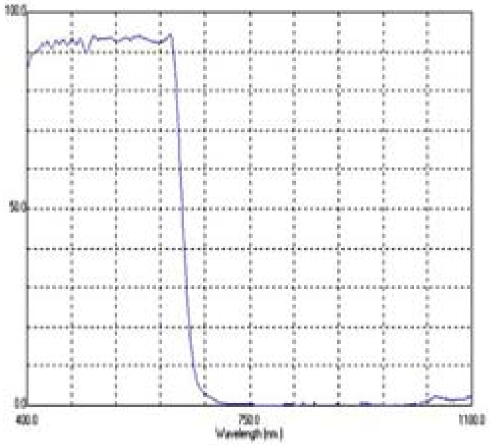

Fig. 3: visual domain transmittance filter

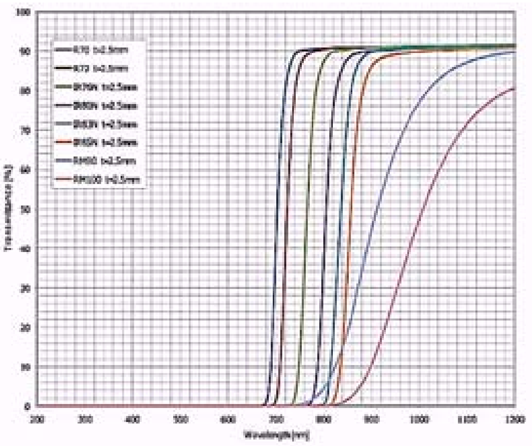

Fig. 4: NIR domain transmittance filter series

Defining dual colors-twins

Our investigations approved that managing dual colors is a very demanding task. As mentioned, irrespective of their CMY or CMY+K composition, they should have the same visual response, examined by colorimetrical and visual means. In NIR domain only K (carbon black) included component should render high absorption, acceptable for instrumental view, entitled as Z image.

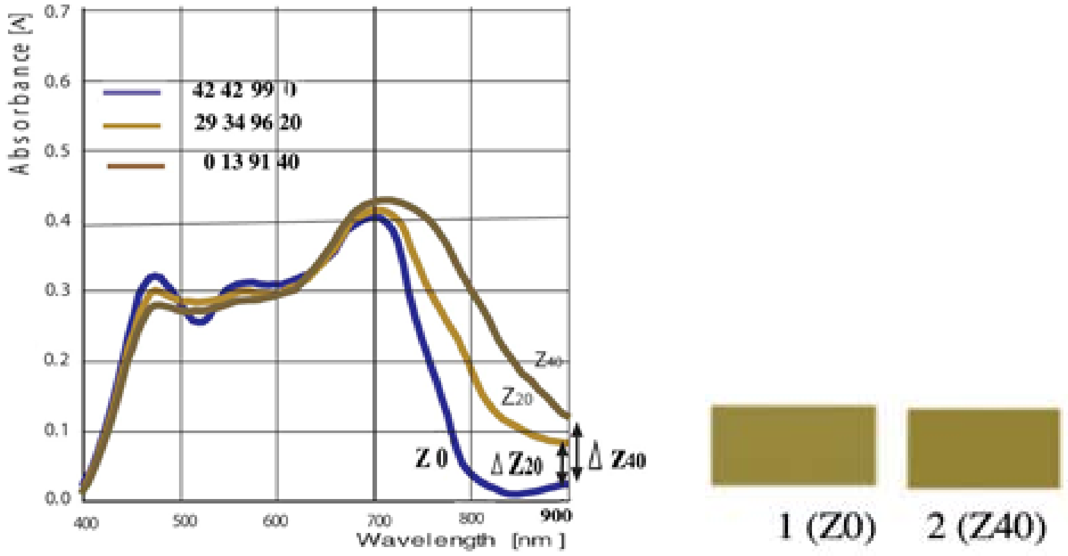

Fig. 5: a twin pair, presenting starting $C_0M_0Y_0$ combination, and combination with **â**20_K and **â**40_K achromatic interchange (courtesy Dr. Žiljak)

One twin pair in a generated image, adjusted for a dedicated printing surrounding is presented on fig. 5. There are several crucial questions we have at adjusting the twin pair. One of them is **â**$_K$ yield. This amount should be a compromise between the lightness, saturation and other values and readability of the Z image. Presented **â**40_K yield is just one convenient example that renders acceptable Z image readings, but can be dynamically alterable, what can be interesting at Z image presentation (7). Another significant feature of K ink in combinations is that basic slope/shape of spectral combinations remains persistent, what is obvious from the fig. 4. Z difference is routed from Z_0 and Z**â**$_K$ absorption/reflection curves (10).
Problem is also targeting the twin colors compositions. As basic combinations involve C/M/Y modulating, whereat aiming some desired hue or other colorimetric value could be rather uncertain. Mathematical models we developed such as those associated with regression analysis, color targeting and similar, but where appropriate, for dedicated purposes or printing surrounding alterations, test patches are produced. Then colorimetric and visual estimations are carried out, and where appropriate, necessary modifications can be made.

Multiple estimation of dual colors

As we ascertain, colorimetric difference ΔE is a criterion, but does not lead to probable desirable primary values composition changes. Program aimed methods are also not always strictly efficient, they sometimes inquire multiple iterations, what implies testing. So we often use alongside a combination of testing methods combining colorimetrical estimations and some dedicated prepared patches for defining optimal coverage twins combinations.
From Fig. 4 we can figure out that in visual spectral curves are overlapping, what implies that visual response should be the same (for the specified printing surrounding)
But, when applying some new surrounding, often we have to start with some basic setting, based low preferences. This could be any scale, including gray scale, rendered

from CMY or simply K, and combined, fig. 6. There are set variety of achromatic (CMY) combinations, and added K values in rather slow step, fig. 6 (9). This approach is useful when setting gray balance, possible additivity, high coverages and TAC, TVI, as well as various printing surrounding specificities.

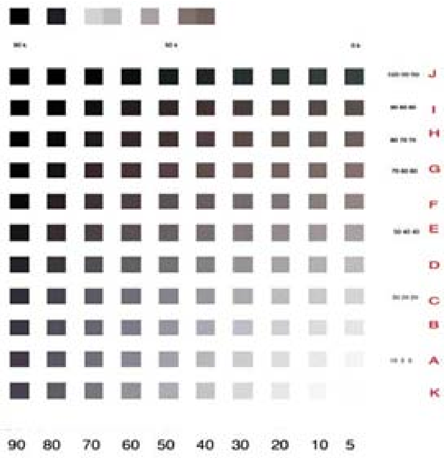

Fig. 6: achromatic combinations chart, combining C-M-Y and K coverage combinations (example)

Such chart can be accomplished in various hue combinations. Another possible option when an color hue is chosen, to establish patches from a chart combination with and without K component, and balance and compare patches visually and measured, as demonstration, shown on fig.7:

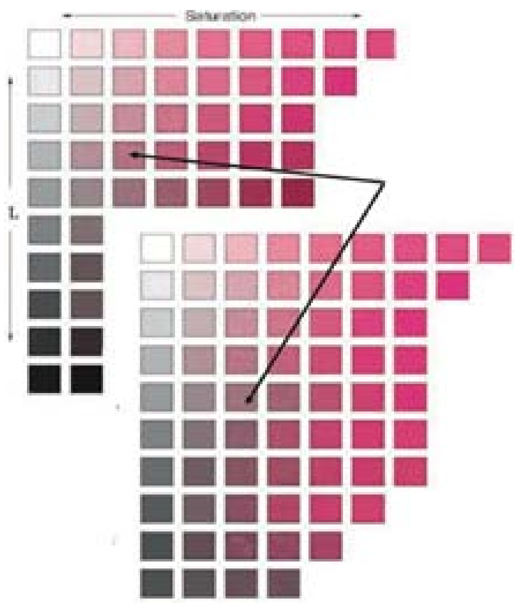

Fig.7: two hue patches arrangement varying L and S, plotted as CMY and CMY+K combinations (example)

In such a combination it is useful to know colorimetric and coverage values. The direction can also be inspected if we colorimetric $L^*a^*b^*$ coordinates translate to LCH mode (demonstration) from fig. 8 (11)

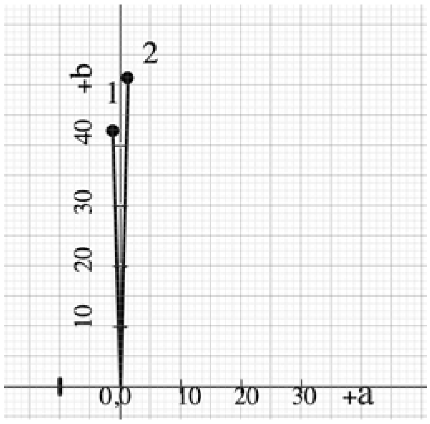

Fig: 8 Patches 1 (Z_0) and 2 (Z_{40}) plotted as LCH. The mutual angle is determined

If we recalculate the angles from observed patches, we also can get some information for correction trend, for facilitate CMY recombination. In this case the shift from $L^*a^*b^*$ coordinates 54 -1 41 and 56 1 46 would be from 88,75 to 91,07 degrees, or possible –a shift direction ($2{,}32^0$), what would imply slight red component reduction, or slight green addition.

All combinations and recombination are realized and colorimetrical examined. Last (but sometimes not the least) is so called “neighbor test” here program means close series of patches are realized in a rather small step, to supposed hue-saturation shift. If more correction needed, subsequent series of combinations follows, with last optimal patch in the middle of the following combination, fig. 9, again checked visual and instrumental.

First correction combination patches

Second correction combination patches

Third correction combination patches

Fig. 9: series of small coverage difference patches toward fine tuning of twin colors

Conclusion

The correction trace is established, but unfortunately we also ascertain that adjustments from one reproduction process are practically not transferable to another reproduction process. All situations where twin colors appear holding secondary image have to be proofed colorimetrical and optical-visual. Only in that case we can be sure that secondary or Z image will be properly stored and be readable with Z camera. We underline, that we developed an environment that make a secondary secured image performed with printing inks features in visual and near infra red domain. Present programing modules do not render fiducially sufficient correct values for double image, se our CMYKIR theory and programing achievements and enhancements are needed for correct double image reproduction. The whole environment covers CMYKIR separation with corresponding theory and twin dyes, specified properties of related inks or pigments, and visualization device or Z camera, already presented.
Aligning proper pairs if colors is a delicate process that simultaneously requests colorimetrical and visual checkout, whereat a suitable practice we deployed, combining colorimetric and visual estimations, mathematical models and regression analysis, combining iterative twin color combinations, that relieved tuning with basic colors/inks/components. Irrespective of all present advancement, further investigate of process, components, methods, implementation is assumed.

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Appendix

Achromatic color is a color that be described only by its lightness

Barrier filters – dedicated filters expressing specific absorption range, in NIR domain used for inspecting reflection/absorption behavior of secured images

Black generation is Color separation methods in four-color process printing that determine the ration of black to cyan, magenta and yellow.

Security graphics – method of protection applied on documents to prevent and shield them from forgery

CMY – basic subtractive system printing inks, obtaining selective reflections in visual domain

Color Visual sensation defined by a color stimulus having a certain chromaticity and lightness

Color difference - Geometrical distance between colors that are plotted in a two- or three-dimensional color space. This metric should be designed to correlate with the magnitude of the perceived color difference. Its measure is ΔE

Carbon black ink – monochromatic ink, often designated as “key” black. Expresses uniform high absorption factor in visual and near infrared domain, usually used by graphic arts printing processes

Colorimetry – science and technology used to quantify and describe physically the human color perception. CIE 1931 standard colorimetric system is Internationally agreed upon colorimetric system of objective color description using three virtual primary colors

Cyan-One of the primary colors in four-color process printing that defines the CMY(K) color space

CMYKIR module – developed program module that renders two images, visual and NIR one in secured pack

Coverage – graphic arts autotypic criterion meaning degree of base overlaying with printing elements

Colorant – dye, pigment or other substance that colors something, achieving some selective absorbance

Chromatic color is a color that can be described by its hue

Dye–natural or synthetic substance used to add color or to change the color of some media

GB – grey balance - relation between C-M-Y amount, providing neutral response

La^*b^*, LCH – CIE colorimetry values

Half tone-image reproduced in graphic arts operation, and autotypic procedure

Human visual domain – part of spectrum, approximately from 400 to 700 nm

ISO – International Standard Organization for Standardization, e.g. ISO 12647 for Graphic technology -- Process control for the production of half-tone color separations, proof and production prints -- Part 1: Parameters and measurement methods

NIR domain – part of the spectrum continuing visual, up to 1200 nm

Patch – pattern with defined combination of inks

Twin colors – pair of colors (dyes) that in visual achieve the same (visual) response, but in NIR differ in absorption rate. In graphic arts they are CMY and CMYK set, but other combination following the same principles are possible

TAC – total area coverage

TVI – tone value increase, deviation that can occur between programmed and printed elements coverage. For basic printing processes defined by ISO regulations

Z camera – photographic equipment adjusted to recognize and visualize hidden image in 1000 nm domain

Z image – image rendered according to CMYKIR theory, visible with Z camera
ΔZ – in NIR domain designated difference between basic CMY dyes and the one with the carbon black combination