Appliance of achromatic arrangement for visual and Z images at NIR technology

Primjena akromatskog postupka za vizuelne i Z slike pri NIR tehnologiji

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Summary
Dual NIR images are often realized through graphic arts printing technology. That procedure in graphic arts commonly assumes autotypic system, including black printer, which can also involve achromatic functions and interchanges. Differences in achromatic usage and meaning between V and Z images we affirmed, including dual colors modulating for images in two spectral domains. Awareness of Z image is to be easy recognizable with dedicated Z imaging camera is due to proper visual and NIR separation that covers spectral region until 1000 nm, including proper disjointing of visual, extended, expanded and Z area. For better adjusting of visual and Z reflection properties we developed advanced methods.
Keywords: dual images arrangements, near infrared domain, black printer, achromatic sequence

Dual NIR slike su često realizirane postupcima grafičke reprodukcije. Ti postupci najčešće pretpostavljaju autotipijski sustav reprodukcije uz prisustvo crne, koja može omogućiti akromatske funkcije i zamjene. Razlike u primjeni akromatskih metoda kao i značenje razlika V i Z slika smo utvrdili, što uključuje t modulaciju dviju slika u dva spektralna područja. Značaj Z slike da bude lako prepoznatljiva sa namjenskom Z kamerom je u ispravnoj separaciji V i NIR područja koja pokriva područje do 1000 nm, te ispravno razdvajanje vidljivog područja, dodanog, proširenog te Z područja. Za bolje podešavanje značajki vizuelnog i Z područja refleksije razvili smo napredne metode.

Ključne riječi: podešavanje dvojne slike, blisko infracrveno područje, crna forma, akromatski ishod

Introduction of common statements

Standard reproduction, based on trichromatic printing subtractive system means cyan, magenta and yellow basic dyes, pigments or inks. They form separate printers or forms, which by means of graphic transfer system, usually screening, create colored image on suitable substrate. Basic separation principle is shown on fig. 1, where separations are displayed with separation filters, and three basic printing forms are achieved. Black printer is added to separations. Achromatic functions are practiced in addition Although synthesis principles were already known, this workflow associated with autotypic principles and coordinated with colorimetric validities (1), practiced for photomechanical applications, as basic, and are applied as well to todays applications and verifications (2)

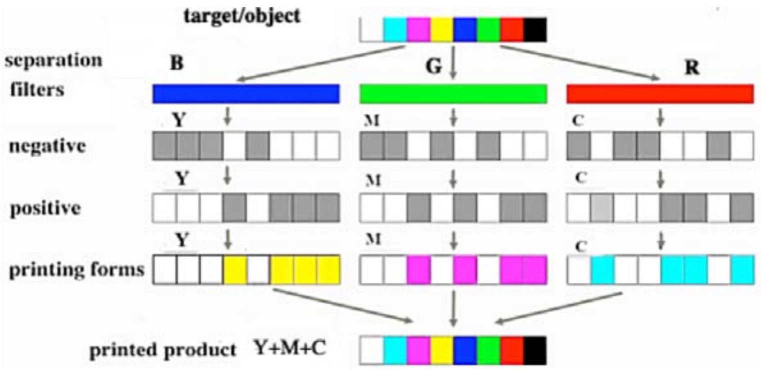


Fig. 1: principle of preparing basic C-M-Y separations

Fig. 2 shows forming secondary color red from primary yellow and magenta colors. Other secondary colors would be performed at similar combinations as green and blue. Tertiary color involves all three basic components, and can accept possible substitutions. Black color, in such arrangement sometimes is designated as CMY black, would be realized as appropriate combination of magenta cyan and yellow coverages, what implies that lightness or gray scale is achieved with three basic colors. Theoretically, that approach would cover the whole visible spectrum, but cause of various graphic arts tenets, color gamut and some other properties are diminished.

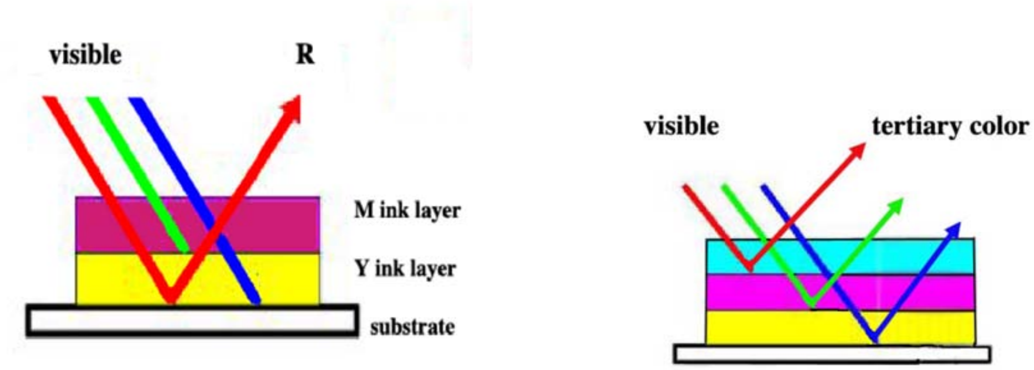


Fig. 2: forming red color experience of a secondary color, red (left), and a tertiary color (right)

To enhance color gamut and some other reproduction features black K (key color, usually carbon black) is added as fourth reproduction color. This practically puts into effect that reproduction in prepress stages forms four channels, which will be afterward conveyed as printing forms. The tone reproduction curve shape of black printer is important for reproduction purposes. That is still not achromatic procedure, but these K values have to be checked. In such “basic” form TAC (total area coverage) can range 360, theoretically 400 percent, so ISO (International Organization for Standardization) recommendations in standard situations, have to be obeyed.

Hue intensity tuning

If we pay attention at CMY model as a cube, gray or achromatic line is a diagonal of initial and opposite points. In such casual way of speaking we could say that “all colors” are in that position. But in other words it comes out, that intensity tuning, meaning lighter or darker, is made by dint of complementary one, fig. 3.

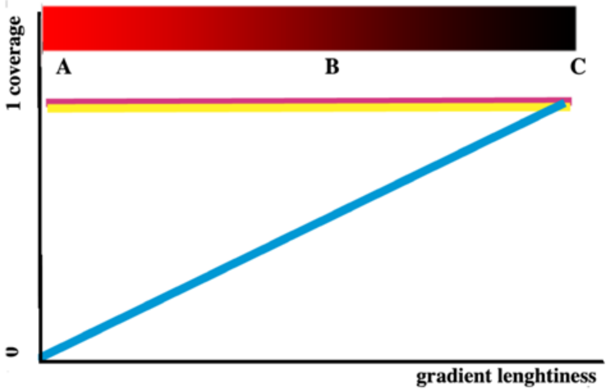


Fig 3: intensity tuning

If we want to make a continuous lightness gradient red to black, lightness factor is complementary color, in observed case cyan. Let us basically consider three marked spots (patches) and their (possible or approximate) coverages $\hat{a}_y$-$\hat{a}_m$-$\hat{a}_c$:

A	90	90	0
B	90	90	40
C	90	90	90

Now are we in situation to consider a possibility of achromatic substitution. Spot A could not be changed, but other two can. Substitution can be made in every increment from zero to maximum possible. Spot B we can change from 0 to 40 percent coverage, as stated:

0 percent substitution, it remains	90	90	0
maximum possible (100% substit.)	50	50	40
e.g. approx. 50 percent substitution	70	70	20

It is obvious that possible ink combination are innumerable, but, theoretically, achieving the same visual output. Spot C is also capable for variety of combinations, but as it presents rather high densities, dark tones and high coverages, we try not to practice such combinations to often. There is variety of reasons for that, such as low reflection intensity of image, usage of high reduction rate is not recommended by some equipment and accessories producers, can effect on image quality, and according to ISO regulations, TAC has to be under control. Moreover we found that moderate exchange satiable our requirements, separation and quality needs, and covers readability using NIR camera.

Achromatic functions at visual images[]

To improve quality of prints (visual), besides black printer, substitution principles are incorporated in separation process. There are available UCR (under color removal for gray scale), CCR (complementary color removal), PCR (polychromatic color removal) for tertiary colors. In all situations adequate CMY combination is substituted with black, in common printing situations, carbon black. Embarrassingly, substitution tuning in most image manipulation apps is stepwise, as: no-low-middle-high. This practically means that on an image each individual pixel can have different reduction rate. On a multicolor (open air) image, if rate is acceptable tuned, possible distortions will be low, in some other sensitive situations reproduction can be problematic meaning trapping, addition laws, ink adhering etc. For NIR images and CMYKIR separation such steps shaped approach is barely acceptable, while reduction interchange is not under control [3] [4]. Additionally, all functions and specifications listed for visual profiles (ICC) have no influence, definition or significance in NIR, except specifications we supported.

Black printer and NIR technology

Black printer and achromatic principles are widely applied for visual images reproduction. Ink reproduction trendlines, coverage response, achromatic rate, TAC, and other reproduction parameters are set up according relevant specifications or specific demands. Colorimetric verifications ΔE, ΔH, ΔC or other relevant Δ values for inspecting image quality are performed also.
According to NIR theory, the role of black channel and printer is considerably modified as we change the wavelength range from visual to extended, expanded and at last to Z domain at 1000 nm where secondary image will be instrumentally identified [5]. In that case black channel and black ink are carriers of the secondary image [6]. It appears differentiation, similar as secondary separation, between chromatic CMY colors (inks), and in printing situations usually common carbon black. We are accustomed to follow reflection/absorption behavior of inks and other materials in visual, but specific spectral behavior exists in other domains, also in NIR. As we stated [7] in NIR chromatic printing inks render rather high reflection. On the other side, carbon black reflection rate is low (absorbance high) and stable in visual and NIR domain. In addition to that, black ink straight line shaped reflection curve form stays alike in ratio from black coverage, when black is combined with some other inks, fig. 4.

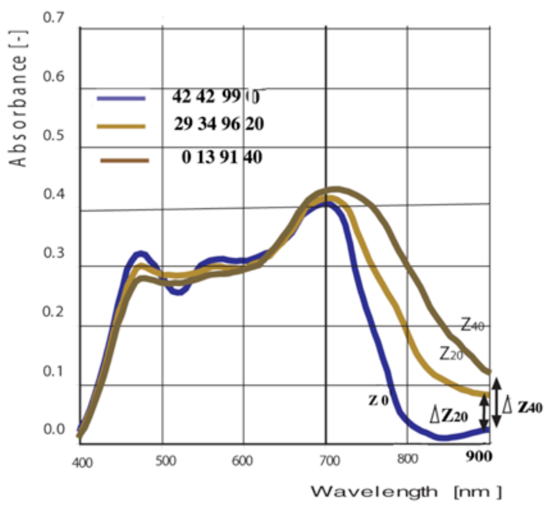


Fig.4: example for different **â**K amount for a selected color, visual the same output, differs in NIR

Investigations proved that **â**K=0,4 complies separation requests and stays constant, as well as Z image readability purposes. Changing **â**K is possible, and setting any reasonable value for dedicated purposes is allowed.
Except carbon black, mostly used at printing procedures, we must fact be conscious that a variety of other pigments/inks/dyes/colorants in NIR express similar absorption properties [8], that can be used in a variety of other implementing, such art paintings, usage at other materials etc, fig.5.

Fig. 5: some art dyes, showing appearance in visual and Z domain, specific absorbances

Dual colors

As we stated before, secondary information is "hidden" in black channel. If we take a look with NIR camera on image showed at fig.5., it would be just a (monochrome) straight gradient line, original size shape. This points out, that for generating hidden information we need a situation that for every image fragment (color) we need to have on disposal two separate information, one as CMY combination, a one as CMY+K combination. Visually and colorimetrical they have to be as close as possible. In NIR domain their reflections differ. Such color pairs we produce, that are visually equal and doffer in NIR, we entitled twin colors or twins. This is the argument that proves chromatic interchange for NIR purposes is not the same as achromatic substitution used in visual domain.
In most situations starting point is RGB to CMY conversion. According to developed NIR separation module on the position of secondary image, K content pixel will be interchanged.

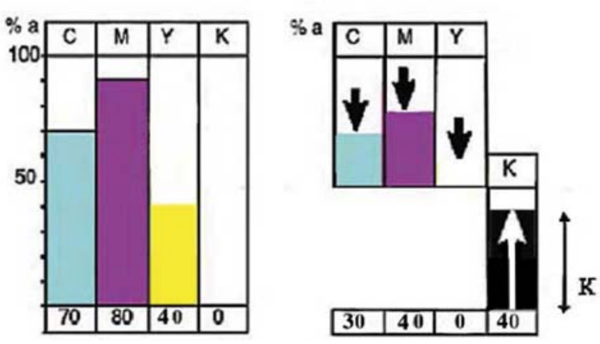


Fig. 6: example of a pair of NIR twins: pure CMY combination (left), interchanged K content (right)

K content distinguishes in NIR reflection curves of CMY and K content twin, but visually they have to render practically the same visual output. Rather unpredictable situation occurs while composing the pair. Rather configuring coverage pairs is not simply linear and single-valued for colorimetric values, so miscellaneous advanced adjusting procedures are developed.
Just comparing magenta patches (fig.7) trendlines coverage versus spectral plots (visual) some notable shape differences can not be noticed (fig. 8), but shifts between coverage curves are not strictly the same.

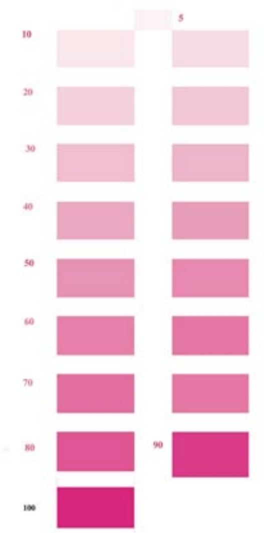


Fig: 7: series of magenta patches coverages from 10-90 % in 10 % step (left), 5% shift (right)

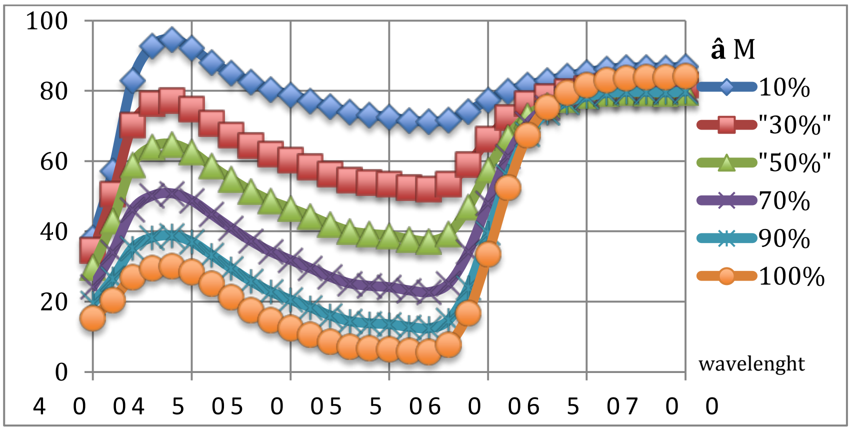


Fig. 8: dependence of coverages and V spectral response for magenta patches

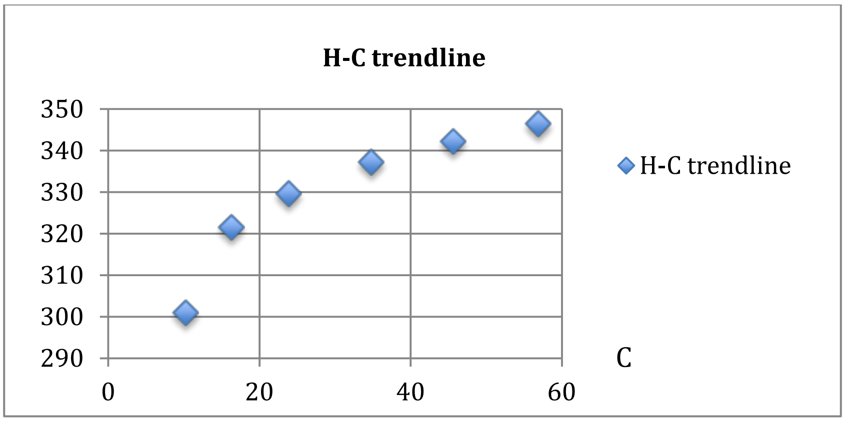


Fig. 9: Lab colorimetric H:V trendline for magentas (according to fig. 8)

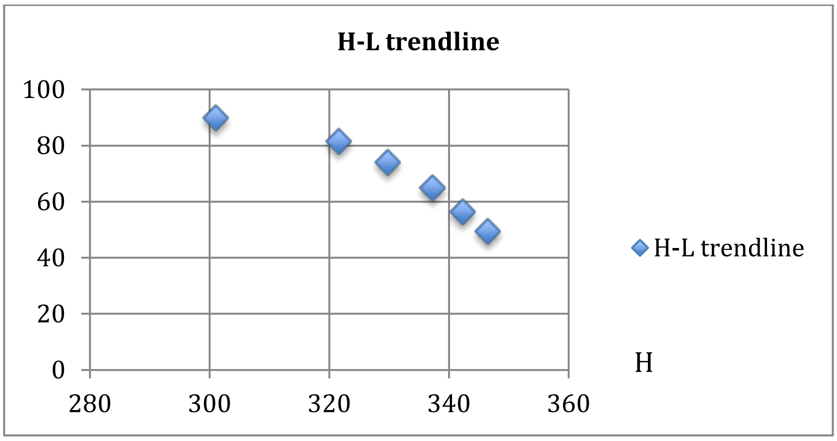


Fig.10: Lab colorimetric H-L trendlines for magenta (according to fig. 8)

If in colorimetric $L^*a^*b^*$ system that should be psychometric, unfortunately observed value trendlines are not in the straight line (**â**M 10-30-50-70-90 observed), what refers that simple estimations of changes in coverage values for adjusting twins are not acceptable. Such changes of coverage parameters can influence to major changes in other colorimetric properties by reproduction, so more subtle procedures have to be applied. Similar non-rectilinear behavior can be perceived at other graphic arts inks, but also at variety of other colorants.

Fig.11 and 12 presents a green twins pair as a reflection plot and spectral density plot according to Lamber-Beer's law. Sometimes plotting absorbtion versus spectral reflectance/absorbance meaning reflection/absorbance factor ($\%T= \log I/I_0$), or spectral absorbance (simplified as density) according to Lambert-Beer law ($A=-\log_{10}$ I/Io as spectral plot) can give us more accurate spectral information, straight portions of slope changes, accept no 0-1 limitation as at absorbance factor of inks or some other colorant combination.

Anyway, the spectral information gives us important information about observed inks, colorants, substrates or other important materials used. In addition to that similar investigations we must perform for other spectral domains, particularly near IR.

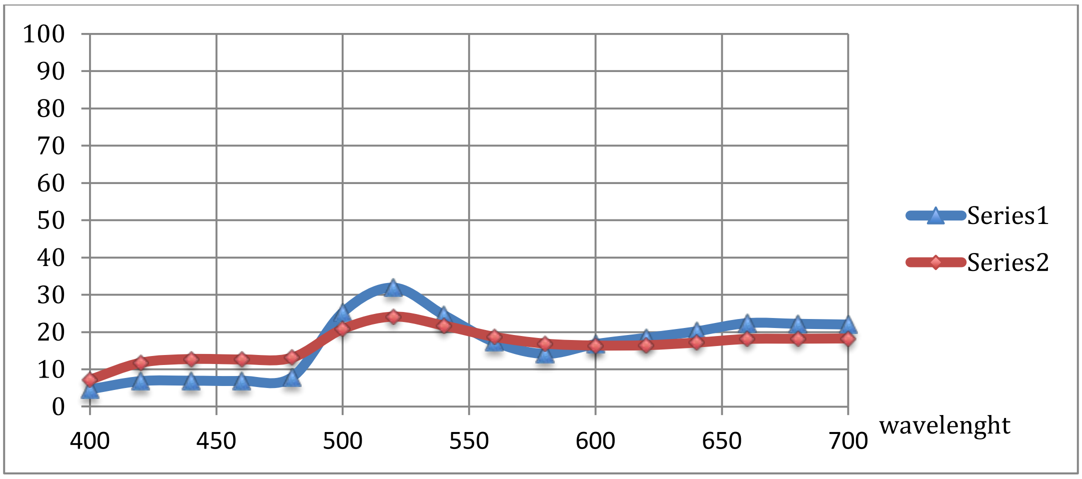


Fig. 11: presents a greenish twins pair plotted as reflection factor/wavelength diagram

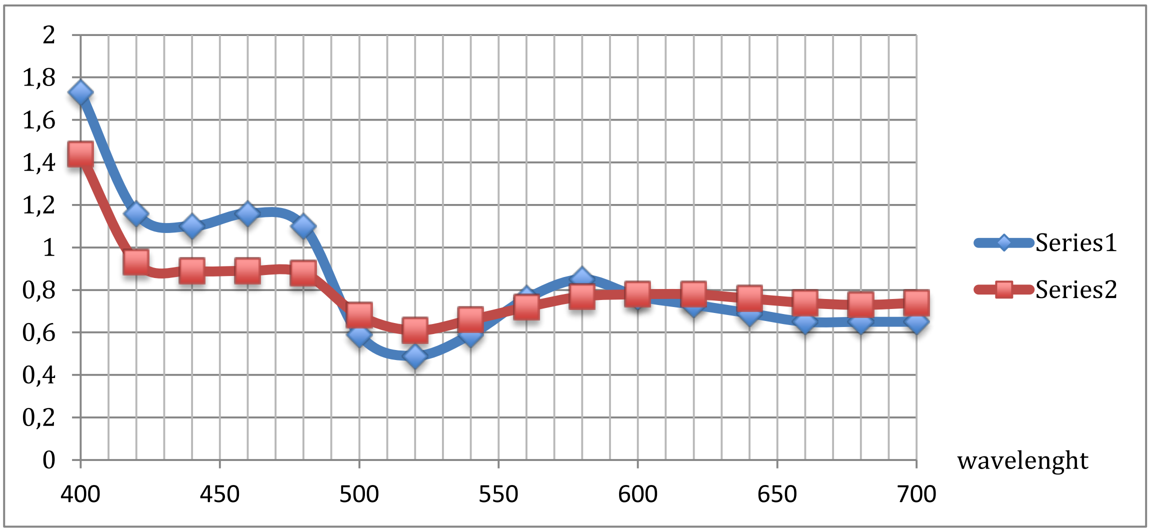


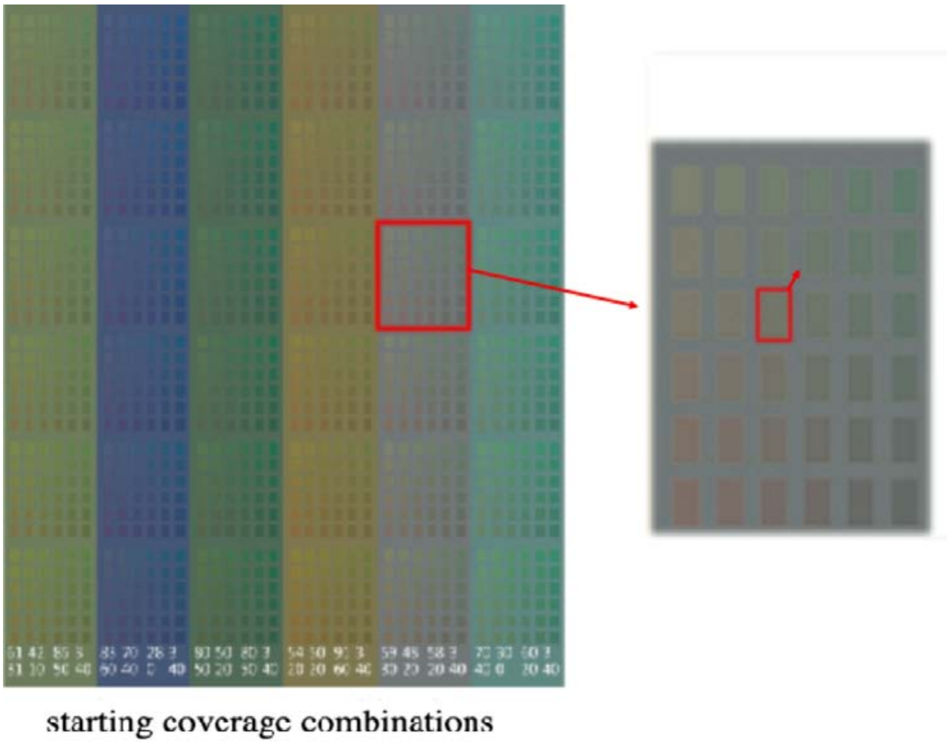
Fig. 12: greenish twin pair as in fig. 11, plotted as spectral density/wavelength diagram

Another important information we achieve from regression analysis of combination as extended, modified, adjusted and customized method of inks combination assessment In addition to that regression model) mathematical model with independent variables and interdependence of X_0 and X_{40} state of dyes, that ensures and protects counterfeiters. These relationships and adjustments are repair of general equations in CMYKIR separation All modifications and alterations we tested finally as printed in small increment steps from calculated values .

Modulating mutual colors for V and Z domain

Assessment of coverages at graphic arts that due other visual experience, as well as corresponding colorimetric values, routes us to rather sensitive and more demanding solutions.

Graphic or achromatic interchange is not a simple process that by argument changes does not influences the final result. Basically it is simple, but in real application it subdues various validities, principles, limitations and misalignment according to targeted reproduction surrounding. After basic statements of no-psychometric behavior in twins surrounding, interesting and consequential approach we achieved through regression admission while interchange application. By multicolor image (eg. landscape) practically each pixel of digitalized image in printing surrounding may achieve interchange different render, including any value from maximal to zero. And notice,” maximal value” of interchange renders at, so called tertiar (three component) autotypic colors, and is alterable. At programmed graphics with infinite number of colors, meaning twins, we must check in V and Z domain. A module creating series of patches, distinguished but defined close combinations is derived (fig.13). This derived image consists six basic color combinations, and six basic changed combinations. Each combination in close neighborhood of central patch changes in small increment other coverage values. So we start with 36 basic combinations. Each patch is targeted to surrounding (basic) coverage value. Starting patch in every combination is line 3 row 3. In this example horizontal step to another patch is 3 C coverage value and vertical 3 Y value. In example (b) central patch (3,3) doesn't fit very well, better combination is (2,4) Estimation is carried out again, and program module reshapes matrix coverages combinations, and repeats the procedure. Patches are often multiple compared, visually and colorimetrical. We must emphasize repeatedly that once defined values are not transferable to another reproduction surrounding.



a b

Fig 13: example if processed image showing different combinations in defined coverage increments (a) and extracted part in blue combination (b)

Conclusions

Creating and preparing an surrounding for realization dual image with hidden and secured graphic is a complex procedure. The job has to be strictly targeted to a defined surrounding such as graphic arts, painting, non standard dyes, various substrates and any designers, engineering or other purpose. We deal with dual reality, visual and extended visual performed instrumentally. We apply absorption/reflection physical and chemical properties of materials used, mostly various inks. In autotypic system suitable carbon black absorption covers visual and Z domain, while Kâ=0,4 is often reference (optimal) combination value between K_0 and $K_{max.}$ that is related to achromatic interchange. Other autotypic inks approximate substrate reflection. On such "model" and developed CMYKIR separation variety of other inks/dyes can applied. In all combinations a consistent dual color combination or series of dual colors we must achieve. Modeling and adjusting or tuning is connected with colorimetric investigations, determining color change direction, tracking regressions, routing and modeling divergences, and ordering required coverages, or some other value.
Colorimetric absorption measurements are always performed, including V but also Z domain, targeting Δ differences as low as possible.
Visual review is needed while colorimetric measurement and representation are connected with defined light sources and other default parameters. Illumination at visual surrounding does not always fit standard illumination conditions, that can be very mixed complex and, may influence visual response and make differences to colorimetric values. Developed viewing module made in real conditions with small increment shifts is a useful additional tool while twin pairs balancing.

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