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To take for granted or question the technology fundamentals in research and learning?

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Abstract

With growing variety of novel printing methods and facilities for their computerized control the rethinking becomes urgent for some fundamental technology issues which just pretend to be clear but are, in fact, the empirical data taken for granted from a long term industry experiences. Based on the research results and educational competencies of author the philosophy of choosing the screen frequency, geometry and press settings, the dot gain nature and multi-purpose use of black ink in CMYK are analyzed and experimentally illustrated.

Keywords: educational paradigm, technology fundamentals, new knowledge, source image, print channel

1. Introduction

Educational paradigm of today focuses on teaching the skills of producing a new knowledge rather on just transfer of what is already known. One of the ways of such knowledge revealing is in questioning discipline fundamentals with finding the explanation to issues, taken for granted on the basis of empirical data and long term professional experiences. Some of them, being familiar to professionals from everyday practice, are used as general basis in defining the values and parameters for industry standards without proper explanation of the physical nature of related phenomena. Lack of such clarity in the questionable issues disclosure makes sometimes the research efforts and educational content to bypass the development mainstream declining to a priori non-actual, low--efficient direction.

Unlike such products of modern “precise” knowledge as radio, TV and internet, the print media stems, to the great extent, from the medieval crafts. Several basic features of the obsolete or still used printing techniques weren’t completely researched or disclosed at nowadays scientific level. It is to certain extent concerned of the philosophy of screen frequency and geometry, of press settings choice, of dot gain nature, of multipurpose use of black ink in CMYK color print reproduction, etc. However, their proper comprehension becomes especially urgent with growing variety of novel printing methods and facilities for their computerized control.

A lot of misconceptions had at the same time appeared as result of superficial interpretations in some handbooks, manuals and professional communication. Helping to adequately appreciate, for example, the “color myths”, Giorgianni and Madden (1998) placed in their book the separate paragraph of such misconceptions analysis in the way of myth/reality withstanding. Similar attempt in relation to “halftoning myths” was also done in Kuznetsov (2009; 2016).

Looking back in the latest history of graphic technology developments one can find a number of scientifically approved recommendations on color values correction for print quality improvement. However, even at the times of electronic prepress, there was a lack of means for proper control of desired variations.

The digital image processing of today allows for practically unlimited print parameter variation with the discretion of just about 25 square microns of ink coverage. Meanwhile, quite a contrary situation of adequate resources but lacking in knowledge of what should be done is often met and the need arises of additional research or training which could substantiate the recommendations and performing methods for effective use of such precise, rather recently appeared control facilities.

Expediency of fundamentals rethinking is far from being confined by below given examples. It can each time arise with appearing the novelties changing the accustomed workflow. They have influence on training content and make an educator to "trim" the "old" knowledge with providing its and "new" one optimal conformity within a course credits limit (Kuznetsov, 2014).

So, it isn't out of place to logically discern some basic notions which just seem to be clear on the shallow questioning background.

2. Optimal print data encoding

In the light of communication theory, the graphic arts picture processing is the optimal encoding by criteria of transfer onto a print through physical press channel as much as possible of a source image data perceivable for a viewer. Such encoding undermines the mutual conformity for properties of original image, channel with its output print and human visual system (HVS).

2.1 Screen orientation in halftones

Representative, useful example of such conformity providing is in the empirically found and over a century used non-orthogonal, 45° screen orientation on a black and white print and, as well, for black separation in CMYK color print reproduction. Its usual explication as making the halftone structure less visible is not exhaustive because the screen is similarly rotated at rulings over 175 lpi when it is not visually acute. Such angling makes the print more informative in general due to taking into account the angular anisotropies inherent in three above mentioned basic components: source image data, channel and HVS. Explanation for the greater informative capacity of image sampling in chessboard order as compared to an orthogonal one was given in the digital TV research (Grudzinsky, Tsukkerman and Shostatsky, 1978) and later on experimentally illustrated for halftone printing (Kuznetsov, 1998).

The first of those anisotropies is in the statistics of contours orientation distribution in images, replicas of a visually perceived world where, due to gravitation, the vertical and horizontal contours prevail over the inclined ones and are, at the same time, of greater importance for a viewer. The other one relates to transmitting channel and is in $\sqrt{2}$ greater spatial frequency response of an orthogonal screen for diagonal lines than in vertical and horizontal directions. The third anisotropy is, at last, in about the same degree less HVS frequency response in diagonal direction.

2.1.1 Angular anisotropies of image data and human visual system

The HVS and above image data properties natural conformity can be demonstrated by the image "Fall" of Bridget Riley (1963) in Figure 1a. Its parallel sinusoids are distinct at reading distance where their lines are vertical. However, the horizontal piece of this picture (marked at side and comprised of inclined lines) looks blurry. Such blur disappears if the image is rotated by 45° making the lines within a stripe vertical.

It is interesting to notice the same stripe looking also quite definitely when separated from the other picture content (Figure 1b). It allows for suggestion that on some higher, cognitive viewing level the brain sacrifices inclined detail definition by redistributing its visual resources on behalf of an adjacent, more important vertical and horizontal ones.

The above specific of visual perception is in a natural way consistent with the mentioned anisotropy in the statistics of contours distribution by their directions in the visually perceived surround. Such harmony does not apply only to a narrow class of images, which include aerial photographs or images of the earth's surface, obtained from space. For them, the concepts of "top", "bottom", "right" and "left" are conditional. At the same time, artificially created images as the typefaces, abstract paintings and the like can hardly be considered isotropic in this sense. Artists choose the strength of lines and contours of different orientations intuitively, taking into account this feature of vision.

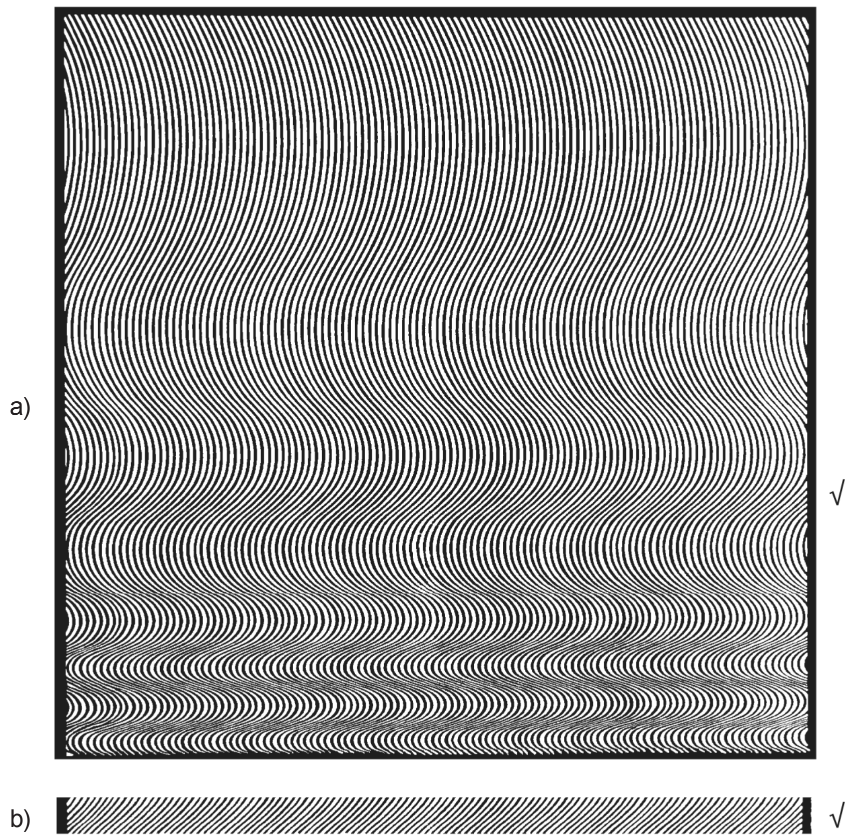


Figure 1: With its inclined lines the marked horizontal stripe of the image looks blurry (a); the same stripe is discerned quite sharply if the image is rotated by 45° or when looking at the separated part of a picture (b), adapted from Riley (1963)

2.1.2 Response anisotropy of a periodic grid

Providing the conformity of the above features of images and vision with the properties of the intermediate graphic processing stage is the prerogative of technology. In this regard, the regular sampling grid resolution can be considered for different directions, not forgetting that the image is divided in printing into separate elements at least twice: in electro-optical analysis and coding of the original, and then in halftoning.

The distance between the dots of the orthogonal grid in Figure 2a is $\sqrt{2}$ times larger diagonally than in vertical and horizontal directions. To the same extent, from 100 % to 70.7 % with an angular period of 45°, the spatial response period of the samples arranged in this order differs. The directions for which the grid resolution is minimal and maximal are indicated there by solid and discontinuous lines.

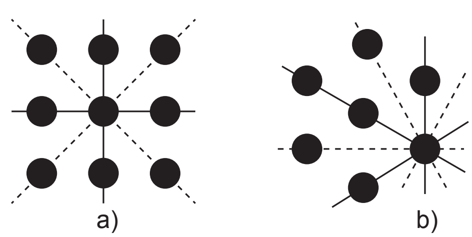


Figure 2: Directions of maximum (- - -) and minimum (—); the response frequencies of the orthogonal sampling grid are repeated after 90° (a); and at hexagonal after 60° (b)

More isotropic in this sense, as shown in Figure 2b, is the hexagonal grid. Its anisotropy ranges from 100 % to 58 %, alternating every 30°. The quality of the transmission by samples arranged in this order depends on the detail orientation to a lesser extent.

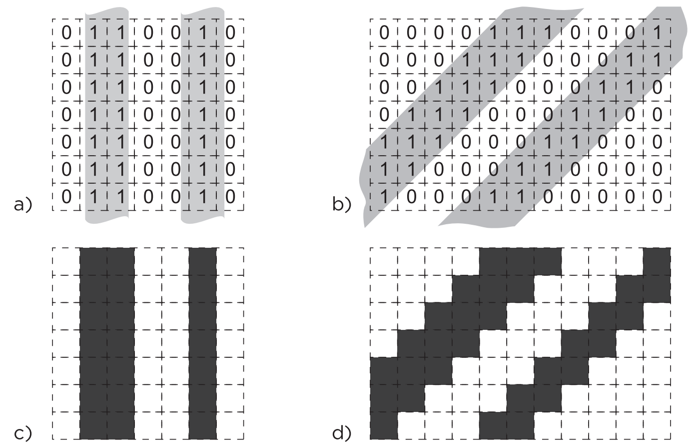


Figure 3: Influence of the vertical (a) and inclined (b) stripes spatial phases in the sampling grid on their width on a corresponding print copy (c) and (d), respectively

For the orthogonal grid, this difference is explained in Figure 3, by the model of digital reproduction of a pair of the same thick black stripes (Figures 3a, 3b). Their spatial phases differ from the original by half the grid period in its horizontal (Figure 3a) and diagonal (Figure 3b) directions.

Line matter is encoded using a simple two-level operator assigning “1”, if the black occupies more than half of a sample area, and “0” otherwise, with the resulting “bitmap” use to print the image (Figures 3c, 3d). From a comparison of the original vertical stripes, their bitmaps in Figure 3a and printed copies in Figure 3c, it is seen that the uncertainty of the stripe width reproduction is equal to the grid period.

As far as the stripes phases periodically replace each other at the smallest inclination from 90° or 45°, the periodic stepwise distortion is added to the error in a stripe width transfer (Figure 4a). If the width is close to the grid step, then the stripe is periodically interrupted on the copy (Figure 4b). For the same reason, the system of thin strokes with an increase in its frequency is reproduced by the false pattern (Figure 4c). Interference of the periodic pattern (texture) of original and the sampling grid is related to the “subject (object) moire” in contrast to the result of color separations interaction in printing resulting in “multi-color moire”.

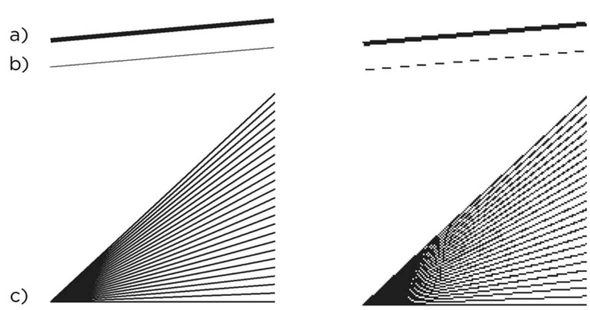


Figure 4: Sampling errors appear in the form of stepwise contour distortion (a), thin stroke interruptions (b) and false patterns in textures (c)

For diagonal stripes, the sampling error is square root of two minus the grid period (Figures 3b, 3d). All mentioned distortions are shifted to the region of about one and half times higher frequencies and become less noticeable.

The considered properties of the originals, reproduction system and vision are made consistent by turning the orthogonal grid by 45°. This position is confirmed by the long term practice of 45° angling the halftone screen for the monochrome pictures and K ink in CMYK printing, chessboard location of the “needles” in matrix printers as well as by the geometry of color sensors placement in the digital camera matrix (Figure 5). Green-sensitive elements are most responsible for the brightness component of the color image and its contours transmission. Therefore, they are doubled in relation to the blue and red ones and are set in the chessboard fashion.

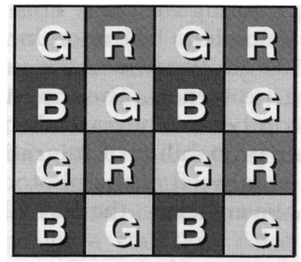


Figure 5: Green-sensitive sensors responsible for image definition are placed in the CCD matrix in chessboard order

It was also proposed to take into account this anisotropy of vision in the formation of irregular screen structures under the conditions of restricted printer resolution, allowing for coarser granularity in the less sensitive diagonal directions (Delabastita, 1993; Allebach, et al., 1994).

Comparison of the effect of different sampling geometries in relation to the reproduction quality is complicated by the problem of keeping equal the all other conditions such as, for example, the screen ruling, sampling rate and source image file volume. Graphical models show in Figure 6 the results of line images sampling and reproduction in the orthogonal (Figures 6b, 6c), and diagonal (Figures 6d, 6e) order. On the right side (Figures 6c, 6e) they were obtained for twice less sampling rate than on the left (Figures 6b, 6d). These images allow for demonstrating the possible signal volume decrease due to the sampling grid optimal orientation at almost the same copy quality.

As in the case of Figure 3, the type fonts in Figures 6b to 6e were obtained for two spatial phases of the original (Figure 6a) in the sampling grid differing by about half at both coordinates. The effect of sampling errors on the quality could be clearly seen by the difference in the uncertainty (variation) of thin lines widths reproduction in each of pairs. At 10 times reduced scale the Figures 6b, 6d correspond to the sampling rate of 100 spi (40 samples/cm), and Figures 6c, 6e to 62 spi (25 samples/cm).

From the pairwise comparison of copies shown in Figures 6d, 6e and in Figures 6b, 6c it can be seen that the spatial phase has less effect on the width of thin vertical and horizontal lines in the diagonal (45°) grid than in the orthogonal (0°) one. This effect remains at the same level for half as many samples if the grid is rotated by 45°, as the comparison of models in Figure 6b and 6e shows. In spite of the error by the root of two higher for the diagonal lines and contours on the model shown in Figure 6e compared to 6b, this does not significantly affect the quality due to the above viewing property. Conversely, the lack of this feature consideration in orthogonal sampling degrades reproduction. Copies presented in Figure 6b and 6e are much closer in quality than in Figure 6c and 6d obtained with the same difference in sample rates.

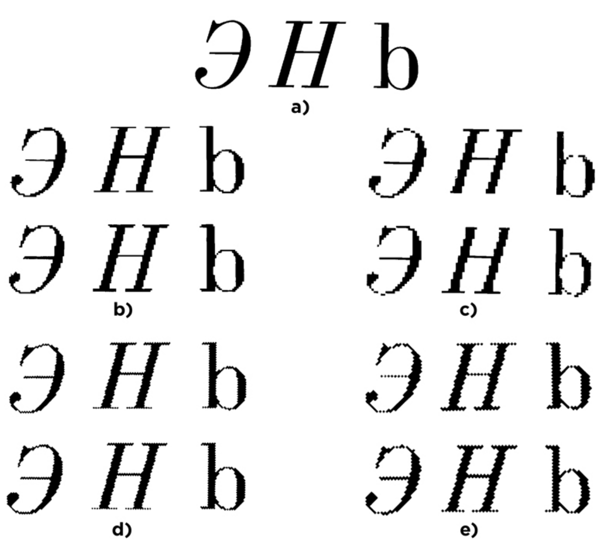


Figure 6: Original details (a) and their copies as result of sampling in the orthogonal (b, c) and chessboard order (d, e); at double (b, d) and single (c, e) number of input samples

Real reproduction is limited with respect to the processed data volume, channel bandwidth and input/output resolution. Under these conditions, orthogonal sampling significantly reduces the representativeness of pictorial data or, as can be seen from the comparison of models shown in Figure 6b and 6e, it is accompanied by its almost double redundancy. Its subsequent elimination by optimal coding (compression) in the system itself gives only an additional effect.

Figure 7 illustrates in real scale the influence of the orientation of both the first (sampling) and second (screening) grids on the print quality. It was prepared on a digital scanner with a screen ruling of 150 lpi (60 lines/cm) and an input resolution of 120 samples/cm. The reproduction quality increases when coming from Figures 7a to 7c with:

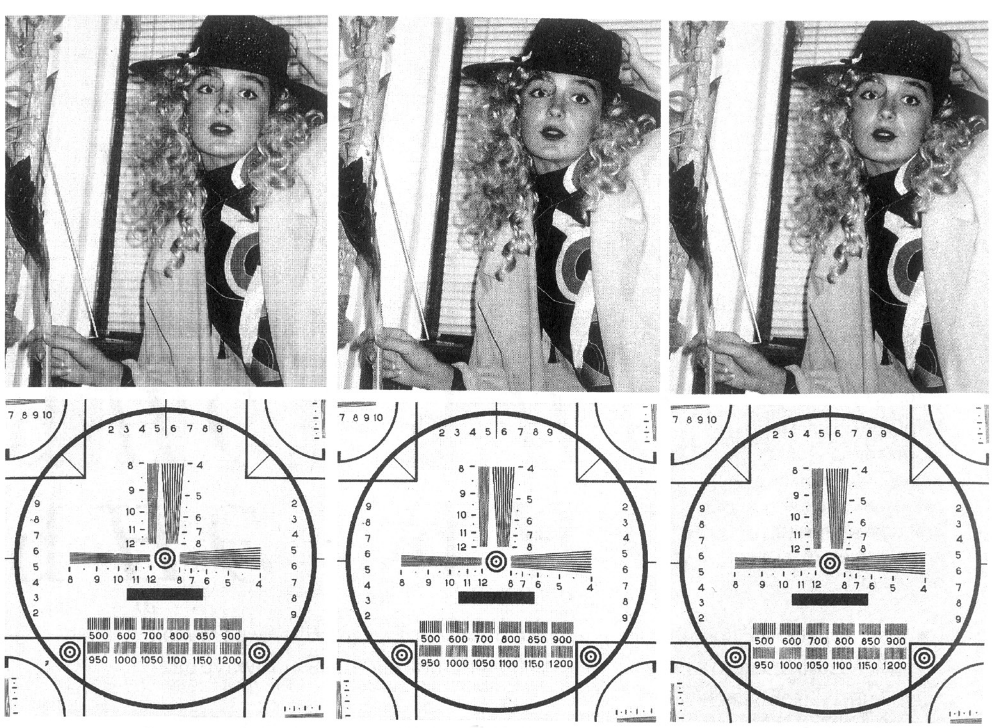
a. both image input and screening grids at 0° (conventional mode for yellow separation);
b. scanning at an angle of 0° and screening at an angle of 45° (as it is used for K ink separation);
c. scanning and screening in a chessboard order.

To establish the difference in quality on the upper realistic images the qualified judgment is required. However, no expert can objectively and even quantitatively assess this difference in form and position of the false pattern on the vertical stripes of TV test placed below.

Presenting the picture in an orthogonal grid at the set file volume unduly lowers the print quality. The same also limits the information content of multi-element light panels, information boards, printing devices, liquid crystal displays and other similar arrangements, although this is not always justified by their design specific.

Theory prescribes at least two-fold excess of the sampling rate in relation to an original image frequency desired to be reproduced on the copy, as well as the sampling and screen ruling ratio, so-called “screening factor” (SF) equal to 2. However, it becomes clear from above why the smaller SF of only 1.5 is quite satisfactory used by the most of prepress operators.

Above considerations on choice of the screen orientation give also some explanation to ignoring the hexagonal halftones by printing practice in spite of their favorable printability. Round dots stay there isolated within about a whole tone range (up to 91 %) while in the square meshes of conventional orthogonal screen they produce the tone



a) b) c)

Figure 7: The quality of vertical strokes shows the influence of the scanning and screening grids orientation on image definition: a) 0° and 0°; b) 0° and 45°; c) 45° and 45°

rendition trouble when touching each other at 79 % ink coverage creating the peak on a dot gain curve, or tone value increase (TVI) curve, respectively. However, the hexagonal screen, with its spatial frequency response variation just on about 20 % for different directions, is more isotropic. So, its rotation is not such effective for providing the conformity of HVS and image data properties.

It is not also out of place to notice that the "electronic/digital" generation of hexagonal halftones, being tested yet fifty years ago (Hallows and Klensch, 1968; Kuznetsov and Uzilevskey, 1976), was later on again proposed with rather disputable motivation of their preferable rosette pattern (Wang and Loce, 2012).

The considered example of taking into account the angular anisotropies of the three main system components (the original image – the carrier lattice – vision) is a clear example of the so-called optimal encoding, the purpose of which is to reduce the volume of the transmitted signal without compromising the print copy quality.

2.2 Press settings and dot gain in halftone printing

Uniformity of "painting" a substrate by some spot color may comprise the basic criteria of press settings in certain packaging job being controlled by the ink solid density distribution over a sheet or the target density match on a control bar patch. However, the strategy of such settings choice for a halftone job should be quite different with taking into account also that halftone reproductions have limited range of tone values (ink coverage), excluding solid tones. Its upper "black level" relates to the ink coverage of 95–97 %, as well as for a "white level" there is prescribed the tint of 3–5 % ink coverage instead of unprinted substrate in ISO 12647-1:2013 (International Organization for Standardization, 2013). These values correspond, in fact, to minimal sizes of a printed and blank elements steadily provided over a sheet within a run for given kind of a substrate, plate, ink, press and, altogether, define the "effective", manageable range of gradation and the picture contrast within the halftone reproduction.

So, the basic criterion of an optimal pressure and ink supply adjustments is, in fact, the providing of minimal possible size d_{min} of a dot. It puts the ink solid standard density value aside as an auxiliary, secondary factor derived from such practice.

The conditions of a tiny ink drop transfer onto substrate are physically different of that for vast inked area. To the pity, a lot of ink–plate–substrate interaction researches proceed from such area properties but are not based on the behavior of a minute ink formation, which size is comparable to a substrate roughness period. Such a tiny meniscus is lacking adhesion as far as it can be just pierced by a filament or hangs over substrate microscopic cave as schematically shown at the left side in Figure 8. For the meniscus of a certain critical size this lacking can be compensated by some excess of a pressure comprising, in its turn, the basic reason of greater drops squash recognized as TVI phenomena. Without said excess there is no problem of gain, for example, for 40 % dots as far as they could be printed of the same or even fewer size which is, however, accompanied by the complete, irretrievable loss of a highlight dots and related tone data. To the contrary, the "natural" tone value increase at press settings aimed on providing said effective range can be compensated in pre-press and it is not out of place to notice here that the effect of such correction in a greater degree depends not on the increase rate but its stability.

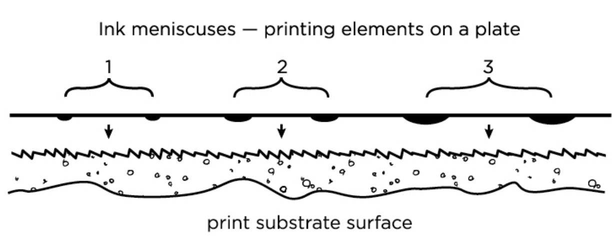


Figure 8: The transfer of an ink meniscus, which smallest size is comparable to average roughness period of a substrate, is unreliable (1); halftone dots of particular area, inherent in given ink–plate–substrate system, are confidently transferred at a certain pressure (2); at such a condition the greater dots are inevitably squashed (3)

It follows from above that the TVI is null for the dot of "white level" on a halftone and the smaller dots are not transferred if they are even present on a plate. Moreover, in flexography their thin stems bend marking the substrate even excessive to a nominal value. Therefore, the TVI curve cannot originate from the origin of coordinates except for analytical models of optical dot gain. Otherwise, it will indicate some imperfection of such a model.

Tone value increase is also caused by the extra inked area at adjacent dots contacting each other. It determines the position of TVI curve maximum cardinally depending on screen and dot geometry. Other reasons are in the 2–3 % dot area change in (obsolete, but still considered) plates photo copying and in optical dot gain. This natural increase becomes even greater due to such obvious causalities as the dot slur and doubling.

These relatively obvious considerations are mostly ignored in the halftone printing modeling research and even in the standards. Pretending on processing the unreal, infinitely small dots they present, for example, tone reproduction curves (TRC) and TVI curves starting from zero value instead of factual, recommended ink surface coverage S_{min} = 3–5 %. This can be seen already in the formulation of the research task itself, such as “The investigation of the effects of different ink density values on color gamut in offset printing” (Tutak, Beytut and Ozcan, 2018) in relation to halftone printing at 175 lpi, rather than “painting” paper with CMYK solids, and gamut estimations, again, within the color boundaries of such layers.

Another example of ignoring the above basic considerations is in almost total shift, since the end of the ‘80s, of halftoning research to frequency modulated screening which explores the digital data processing advantages with the use of a mathematically elegant error diffusion algorithm. Over two decades the papers, patents, doctoral theses, handbooks bypassing the developments of traditional and still widely used halftoning but exclusively devoted to its, so called, “stochastic” version, dominating in the literature. Ignoring the above discussed fundamental issues of a plate–ink–substrate interaction, this version had, however, found rather limited practical application (Kuznetsov and Schadenko, 2017). Use of a minimal dot within the whole tone range makes them very sensitive to printing tolerances. (It is easily evidenced by the attempt to print a 50 % tint of the chessboard located minimal dots and blanks).

These considerations on seeking the “sweet spot on a press” by criteria of providing the effective tone range may serve as a starting point for the philosophy of halftones frequency choice.

2.3 Logic of the screen ruling choice

Ruling value for given kind of job is usually set according to the industry experience but the particular meaning is not somehow substantiated in spite of its cardinal effect on informative content of a print. Halftone of 100 lpi incorporates twice greater amount of data than at 70 lpi and the print area cost is usually estimated per square inch in advertising.

There are met the superficial conclusions of ruling upper level of 150 lpi (60 lines/cm) being quite sufficient for all kinds of jobs as related to HVS frequency response limit of about 6 lines/mm at reading distance (Raskin, et al., 1989; Kipphan, 2001). Such a halftone can however reproduce just the 3 lines per mm of pictorial data. So, the practically unreal, twice higher ruling of 300 lpi is required to completely satisfy that kind of “theoretical” supposition.

It is not out of place to mention that halftone structures at all practically used ruling values, in spite being, if desired, resolved by normal viewing, are usually ignored by observer on behalf of discerning a thereby carried informative detail. Vision behaves similar to the low pass spatial frequency filter with its threshold adaptively moved according to viewed content. Lattice of 35 samples/cm is appreciated as sufficient pictorial data on a halftone of 175 lpi (70 lines/cm) in a magazine. However, the same frequency of 35 samples/cm is ignored as not related to an image data when screening with 90 lpi (36 lines/cm) for a picture in newspaper. Such phenomena are confirmed by sincere surprise of some people unfamiliar with the “trick” of halftoning when their attention is put on a specific dot structure of such images. It often happens that they have earlier appreciated them as usual continuous tone photographs.

Overall image quality can be, in general, estimated by the sum of its multiple parameters weighted according to their “just noticeable differences” relative importance for a viewer. As far as the ruling value L, responsible for image sharpness and definition, is in wide practice reduced at coming to coarser print substrates and processes it is possible to propose that these parameters are somehow sacrificed on behalf of providing some others. Such, much more important, principle parameter is the image contrast. It is defined by the reflection ratio of “white” and “black” point settings in the reproduction process.

With the measurement tolerances at that lower bound it is quite possible to assume the tiny dot value, characterizing above mentioned process facilities, as S_{min} = 4 %. At presumably square form of such a dot its size d_{min} comprises the fifth part of a screen period $1/L$ which gives the rule of thumb for ruling calculation: $L = 1/(5d_{min})$.

Inverse equation $d_{min} = 1/(5L)$ allows, from the other hand, for rough judgment of certain screen ruling value and process facilities conformity in providing the desired image definition and sharpness.

Table 1 contains L and process characterizing d_{min} values which conform to such a rule and quite correlate to practice. Meanings from ISO 12647-1:2013 do not, however, completely follow certain logic. While recommending the “white” point of 3 % for rulings of 60–175 lpi, it prescribes 5 % for 200 lpi, i.e. advises, by unknown reason, to lower contrast for “art” printing by making this point 2 % darker. In spite of the use of higher quality substrates and precise processes, the minimal dot becomes at such a condition even greater than at 150 lpi.

Table 1: Screen ruling L and process characterizing d_{min} (approximate) values conforming to the rule $L = 1/(5d_{min})$ at a “white point” of 4 % and correlating to industry practice of contrast priority over print sharpness and definition

	d_{min} [μm]	L [lpi]	[lines/cm]	S_{min} [%]
Newspapers	80	60	25	
	50	100	40	
Magazines	40	130	50	4
	33	150	60	
Commercial	29	175	70	
	25	200	80	

Another example of ignoring the logic of screen ruling choice is in the often met boosting of processes, consumables and equipment potential by stating the facility of operating with a tiny dot of 1 % or 2 %. Such dot availability (if properly measured) allows for twice or one and half greater ruling which results, in its turn, in four or two times larger volume of pictorial data at a print of the same size.

Neglecting above logic of ruling choice had place in flexography greatly demanded in recent years for colorful packaging. Overestimated screen frequency created there a problem of tone “breakage” in highlights, which had required the special solution of development the modified, so-called hybrid halftoning.

A large number of articles devoted to screening opens with a figure of the “original”, issued as a continuous tone test image. Further comparison of the effectiveness of the proposed and alternative methods is illustrated by copy versions thereof. That in itself the original is printed in the edition with use of a regular screen and therefore is not the continuous tone, and that its quality far surpasses all other images given by the author is not taken into account. So, we have had to underline the importance of well-grounded relationship of process facilities and screen ruling value for the correct comparison of different halftoning methods (Kouznetsov and Alexandrov, 1999).

The relatively low resolution made an obstacle in obtaining the conventional screens and their frequencies in digital printing. In spite of providing the proper image contrast it had the shortened halftone dots alphabet reducing the amount of tone responses within reproduced range due to the limited discreteness of a screen cell. The number of patented technical solutions of various vendors was used to overcome this problem (chapter 4 in Kuznetsov, 2016). In ink jet it was, for example, solved by means of the *multilevel* screening with adding the diluted CMY inks to the CMYK process ones. In electrophotographic, “laser” printers there are for the same purpose used the increased spot function addressability as well as the partial frequency modulation of dots placement (the hybrid screening).

The above principles of screen ruling selecting stay meanwhile true against the background of an extensive range of halftoning options in modern raster image processors (RIPs) for computer to plate (CtP) output and digital printing.

2.4 Black ink in CMYK color reproduction

Other example relates to the use of a fourth, black process ink in color reproduction. Seemed familiar to each printer it, at the same time, as was shown in Kuznetsov and Ermoshina (2015), is rather tangled even in its definitions. Some attempt was done there to logically discern the multiple purposes and functions of theoretically infinite continuum of CMY to CMYK transformations. One of these functions (achromatic CMY component replacement by K) is stipulated in its volume and range of applying by the number of such technologic, economic, operating and image quality considerations as:

- total ink limit;
- ink consumption costs;
- fidelity and stability of the grey balance within a run;
- color disbalance, moiré and rosettes visibility due to their geometry variation;
- gamut mapping intents;
- use of inks of complementary to CMY colors in Hi-Fi printing, etc.

However, there are also the other reasons of K ink combined use with CMY such as:

- reproduction of achromatic colors themselves;
- providing the darker chromatic ones to expand a print color gamut.

Black ink applying can also differentiate from the vast, stationary image area to its sharp boundaries and fine details. Due to considerable reflectance in near to infrared illumination it is even used for the print security purposes.

Black ink complementing to CMY process ones has started at the times of camera prepress where facilities of its control according to certain rendering intent and, especially, for its one particular effect on the resulting color were rather restricted. However, the mostly heuristic found, scanty collection of black ink settings is until now used in wide practice. One of the reasons is in some isolation of numerous participants (publishers/advertisers, prepress operators, quality managers, printers…) from each other. Moreover, coming from one under color removal (UCR) or grey component replacement (GCR) curve of Photoshop to the other inevitably changes color of the same print area due to variations in halftone dots overlap, their summary perimeter, etc. resulting in the shift of an ink trap, physical and optical dot gain, etc. Resulting color also strongly depends on the “dot-on-dot” or “dot-off-dot” strategy choice of inks placement (Rhodes and Hains, 1993). So, almost an each time of K use variation the new color profile is formally required through an accurate press “fingerprinting” procedure.

Lack of facilities to find the optimal adjustments ultimately matching the job/process specific makes practitioner to follow the narrow path of guaranteed, standard parameters (Euroscale, SWOP, etc.) or of settings stipulated by the accustomed ICC profile.

One else reason of non-optimal black ink use is in vague interpretation of its settings and their essence in “black boxes” of prepress software applications or commenting manuals. When appealing to their “help” option the user is sometimes sent to get an advice from a printer. In this relation was noted, for example, that only about a quarter of the Swedish print houses have people ever heard of the UCR and GCR functions of Photoshop (Enoksson, 2004).

Not so much “help” the user can get from academic sources. Problems start here from the lack of these functions proper definitions. For example, both UCR and GCR indicate in fact the “removal of chromatic inks (CMY) achromatic component by replacing it with the black (K) one”. Meanwhile the “Complete Color Glossary” defines the UCR procedure as related just to the dark neutral colors (Southworth, McIlroy and Southworth, 1992). In the “Handbook of Print Media” (Kipphan, 2001) the UCR, GCR, UCA are distinguished by just the volume of CMY achromatic part variation replaced by black, though this volume can be as well changed along the tone range within each of these procedures. The GCR is also stood out as a “generalization” of UCR and K addition (Balasubramanian, 2003). There were also the attempts to modify K use under the names of programmed color removal (PCR), integrated color removal (ICR), etc., and the new ones were proposed (Enoksson, 2004). The number of other explanations of a fourth ink applying suffers from mixing the purpose and method of destination.

On background of a “Black and White” importance “in color” (Hunt, 1997) the lack of a K-ink use adequate clarity results, in its turn, in generating the persistent, widespread myths in related technology aspects. One of them was until now used for stochastic screens promotion, however, the moire problem can also arise with introduction of complementary RGB colors in CMYK color reproduction process within the Hi-Fi print concept. In reality the complete, 100 % removal of one of CMY inks is compulsory to make worthwhile the use of an additional ink of opposite, complementary color for gamut expanding. So, the conventional, periodic screen is safely used at an angle of corresponding process ink as far as the chroma increase can be achieved just at condition of entire removal of the latter in particular image area. It is appropriate to mention at the end of this section the relatively recent problem of achieving the reliability of color in printing.

For many years the hard copy (slide, photograph, drawing...) was used as a source image for print production. Its properties could be objectively measured by the densitometer or colorimeter in job characterizing. For modern open, network printing environment there was also the “color management system” developed providing the identical image data defining at different locations.

New challenge to such data adequate interpretation is in digital photography of today presenting it in an image file. Factual color meaning of its values are properly defined just at a special professional level by the use of profiles accounting all the conditions of an image capturing in the so called “reference input media metric” (RIMM). However, in a wider, common use of such files the reproduction stays rather colorimetrically indefinite which negatively affects a print result and its prediction. So, the generalized solution for an input color meaningful interpretation is in the direct providing an image three component colorimetric value from the signals of multispectral camera.

3. Conclusions

Along with reducing the screen visibility its rotation on 45° doubles the image data volume in given printing technology and to the same extent reduces the image file size.

The basic criteria of an optimal pressure and ink supply adjustments for halftone job is the providing a dot of minimal possible size d_{min}. So, all the TRC and TVI curves should start not from the zero but from corresponding S_{min} tone value of about 4 % since there is no gain at all for such a dot.

At presumably square this dot form the rule of thumb $L = 1/(5d_{min})$ can be used for the screen ruling choice quite correlating with practice. Inverse equation $d_{min} = 1/(5L)$ allows for checking the screen ruling value and process facilities conformity in providing the desired image definition and sharpness.

The use of black ink in CMYK printing is due to many factors not fully investigated in their totality and very conservative, since the change of K ink settings affects the output color requiring the renewal of a printer profile.

In the widespread use of digital photography files as originals for reproduction, the interpretation of object color meanings remains rather uncertain. The potential solution of this problem lies in the spectral image capturing.

Approach, which reveals the principle questions have still to be answered on the background of intensive technology innovations, makes the researcher or learner more encouraged to creative professional activities than the simple transfer and assimilation of existing knowledge leaving the impression of everything had been already explained and solved.

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