Method Development to Control the Identity of Reproduction Print

Sergey Dydyshko, Sergey Gulyaev

Quality control of print should be observed in two aspects. First – conformity of the print to the original, second – the stability of circulation. The first aspect has a large subjective component, especially if the color coverage of the process of reproduction is insufficient for exact reproduction of the original. The second aspect is usually objectively controlled by the system of test-objects, however, due to an indirect way, it always leaves place for disputes. Recently, in connection with the development of information technology, systems of estimation of image quality and printing process, based on computer processing of the scanned print, have begun to appear. The offered method refers just to this direction and is relevant both in scientific and practical terms.

1. Aims and objectives of the research

The main scientific objective of the research is to develop an objective device-independent technique for assessing the quality of the printed image and establishing its conformity to the original.

To solve the main task of the research it is necessary to consider is better the following problems:

1. To perform analysis of the technological and technical characteristics of a controlled object (print).
2. To define the parameter which will determine the way of controlling the identity of prints.
3. To perform analysis of the existing ways of segmentation of digital images. To develop an algorithm for segmentation of the analyzed image in areas with equal brightness-chromatic characteristics.
4. To develop algorithm of quantitative analysis of properties of the isolated segments of the image. To run the calculation of the segmented sections area with equal brightness-chromatic characteristics.
5. To develop zones of maximum permissible deviations from the absolute value of the investigated parameter (segmented sections area value).
6. When the listed problems are solved, it is necessary to define the form of comparison of investigated parameters to prepare the conclusion about the conformity of quality of the analyzed image to the reference sample.

2. Hypothesis of research

In the research it is assumed that for the estimation of conformity of the reproduction quality of the printed image it is possible to use digital three-dimensional model of the analyzed image.

The solution of these problems is based on the possibility of representing the two-dimensional image in the three-dimensional basis. Thus, the spatial coordinates of the image are directed on lengthways axis x and y, and luminance coordinates (optical density) – along z. The image represented in such form looks like a certain "landform" in which the magnitude of «peaks and dints» is set by the magnitude of brightness (luminance), and character of their formation in the space – by the magnitude y. Dissecting the "landform" parallel to OXY plane with some interval ΔL (D), we receive a series of the cross-sections is obtained squared value of which will characterize the certain half-tone characteristic of the image [Dydyshko, 2007].

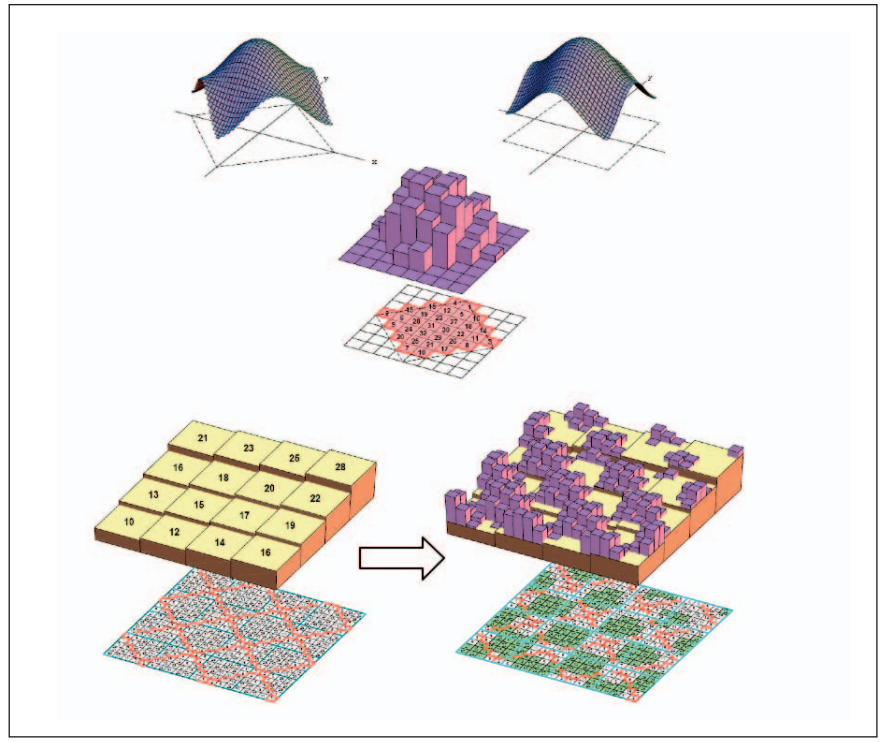

Figure 1: Model of distribution of the half-tone characteristic of the image on its area

After the area occupied with sections having equal half-tone characteristics on the image is evaluated, the diagram, on which the meanings of all the evaluated areas for the analyzed image are placed successively, is created. Then comparison of the gained meanings for the investigated image with the corresponding parameters for the reference image is performed; on the basis of the results of this comparison a conclusion about the identity of the analyzed printing image to the original is made.

Defining the characteristic, on the basis of which the analysis of quality of printing images is made.

The basis for development of an objective method for controlling the identity and the quality of analyzed print implies finding the characteristic parameter, that can be determined by disposable technical means and allows to define operatively half-tone and chromatic parameters of a print.

Thus, the objective parameter defining the identity of print, within working thickness of inking layers, is the value of the luminous flux reflected from the controlled areas of the printing image illuminated by a stable light source and, specifically, the value of the segmented areas with equal half-tone and chromatic characteristics. The control of the image by means of such values is more consistent with the visual perception process, than the control of quantitative analysis of brightness or color coordinates on separate image elements. The observer is more likely to find the most important, distinctive characteristics of such a type as contours or textural areas and to form from them the combinations subject to be recognized. With such understanding of the visual perception process it is logical to control the reproduction of the image by its characteristic features (the areas with equal half-tone characteristics), and not just by its separate elements.

One of the primary problems of the research provided was the development of the segmentation algorithm of the half-tone image based on the processing of the analyzed image by a multiple threshold. As a basis for the definition of threshold values threshold density values of the discriminating sensitivity of the eye have been as-

sumed. Therefore, being based on the postulates offered above, the algorithm of the segmentation of the areas of images with equal half-tone and chromatic parameters has been developed and mustered experimentally.

The execution algorithm of the given operation represents the cyclic processing of the analyzed image by the means of the vector-mask whose values represent a multiple threshold. Then the image is divided into channels. In each of such images, according to the developed algorithm, we gate out the areas with equal intensity. As a result the image massif is divided into layers in compliance with the vector of threshold values, which contain the information about the distribution on the areas sections with various brightness thresholds.

Next, using the gained matrixes, we compute the areas (the area value corresponds to the quantity of pixels) that occupy the sections with equal half-tone and chromatic characteristics. Thus, from the gained distribution of values of half-tone and chromatic characteristics on the image area, we construct a graph; on the axis OX we plot the value of the half-tone characteristics of the image, and on the axis OY - the value of the area occupied with this half-tone [Dydyshko, 2008].

For the reference image (the approved print in relation to which the quality of the printing image is determined) an interval of admissible deviations for the values defined above the areas is defined. For this purpose two additional images for which the color difference at every point corresponds to the requirements of standards in the field of quality of print production are created. To define the upper bound of the tolerance of the reference image the value in color system CIELab for the channel L is increased by 1,5 units, and values of channels a and b - by 1 unit. To define the lower bound of the tolerance of the reference image the value for channel L is reduced by 1,5 units, and the value for channels a and b – by 1 unit. As a result, two images, with the minimum and the maximum admissible (considering that ΔE should be no more than 4 units) values of half-tone and chromatic characteristics are obtained. For the gained images the operations of image segmentation on the sections with equal brightness are performed. The values of the areas with the set parameters are defined. One profile for two distributions of the analyzed characteristics (max and min) which have been received is constructed, on the axis OX the values of the graded characteristic of the image are plotted, and on the axis OY – the value of the area occupied with this half-tone. The interval of values which keeps within a zone contoured by profiles is a required gamut of the admissible change of controllable parameter for analyzed images, within whose limits, a conclusion about the identity of the investigated image to a reference print can be made.

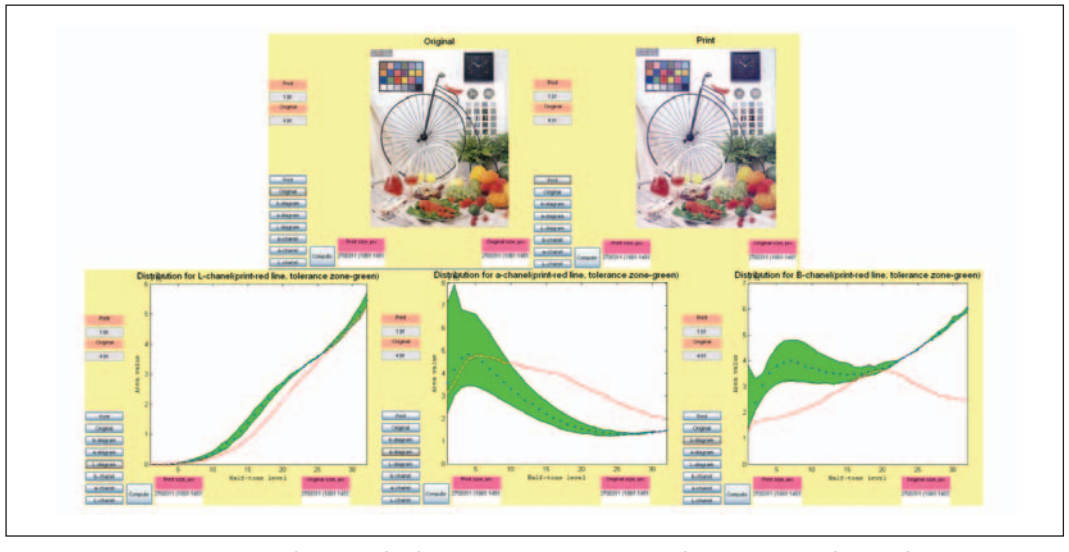

Figure 2: Represents the distribution of the areas of half-tone and chromatic characteristics for analyzed images for each of the processed channels in the system CIELab; it also represents the interval of a legitimate value for the defined characteristics. The derived dependences allow drawing a conclusion about the conformity of analyzed images to the reference sample.

3. Influence of technological printing conditions changes on the proposed method

To determine the efficiency of the proposed method for assessing the quality of prints using digital simulation of the images the following experiments were carried out:

- test prints, made under different technological regimes, primarily print speeds: 5000 ott. / hour, 6000 ott. / hour, 8000 ott. / h, 10 000 ott. / h, 12 000 sheets. / hour, 14 000 ott. / hour., which inevitably led to a change in optical densities, were obtained.
- printing with increasing and decreasing the overall density of all colors on 0,3 B was carried out.
- printing of test images with printing plates offset for cyan and yellow inks to 0.1 mm., and 0,3 mm., and 0,5 mm. was performed.

Impact of changing the values of the zonal optical densities of the printed image on the proposed method

The table shows the values of zonal optical densities, obtained by densitometer, for the analyzed image

Optical densities of the inks	Reference image 4	Image 1
Cyan	1.4-1.46	1.3-1.46
Magenta	1.42-1.5	1.41-1.44
Yellow	1.31-1.32	0.78-0.82
Black	2.6-2.67	1.35-1.48

Table 3.1: Values of the zonal optical density of the test images

Figure 3.1 shows the distribution of luminance-chromatic characteristics area for the analyzed images for each of the processed channels in the system CIELab. It also displays the allowed values interval for the defined characteristics. These dependences allows to make a conclusion about the correspondence of the analyzed images and the reference sample.

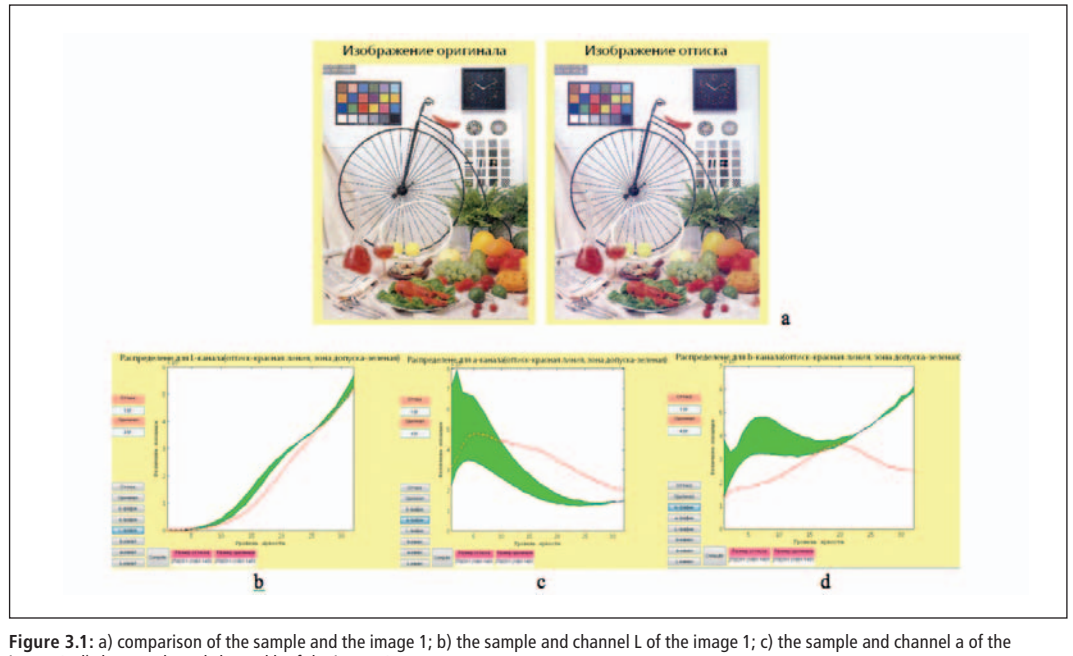

Figure 3.1: a) comparison of the sample and the image 1; b) the sample and channel L of the image 1; c) the sample and channel a of the image 1; d) the sample and channel b of the image 1

Presented dependences illustrate the correspondence of obtained data to visual perception and the traditional methods of printed images control. It should be noted that these experiments with changes of optical densities of different triad colors allow to make the following conclusion: changes of the zonal optical densities of colored triad inks considerably change the colorimetric characterisrics of the print, i. e., one can see sharp values changes of a given indicator for channels a and b on the presented curves, as well as deflection of the general image contrast (the determining indicator is out of limits for channel L).

Impact of changing the brightness of the image on the proposed method

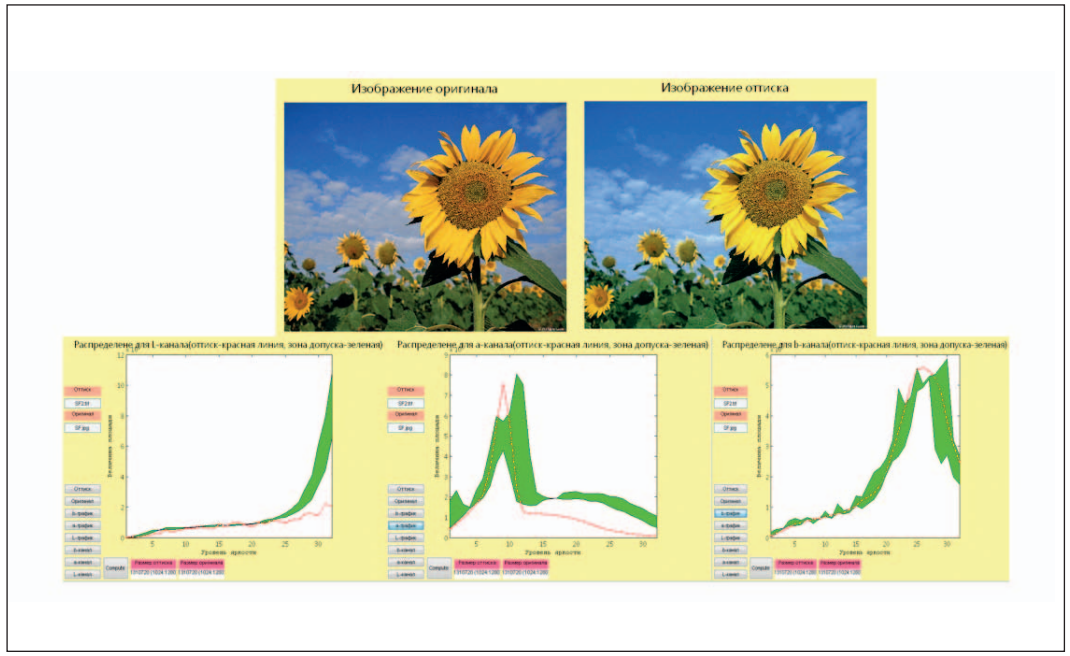

Figure 3.2: Comparison of data obtained from the experiment of he image with a decrease in the overall brightness (decrease in optical density of all the triad colors on 0,3 B), in the system CIELab for each channel.

The performed experiments of the optical density changes of all the triad colors provide an opportunity to make a conclusion: a change of the overall print brightness (the total amount of ink) has the greatest influence on changing the analyzed parameter in the channel L, i. e., on the gradation characteristics and image overall contrast, which leads to a deflection of the colorimetric characteristics transferring of the print.

Impact of printing plates offset of the printed image on the proposed method

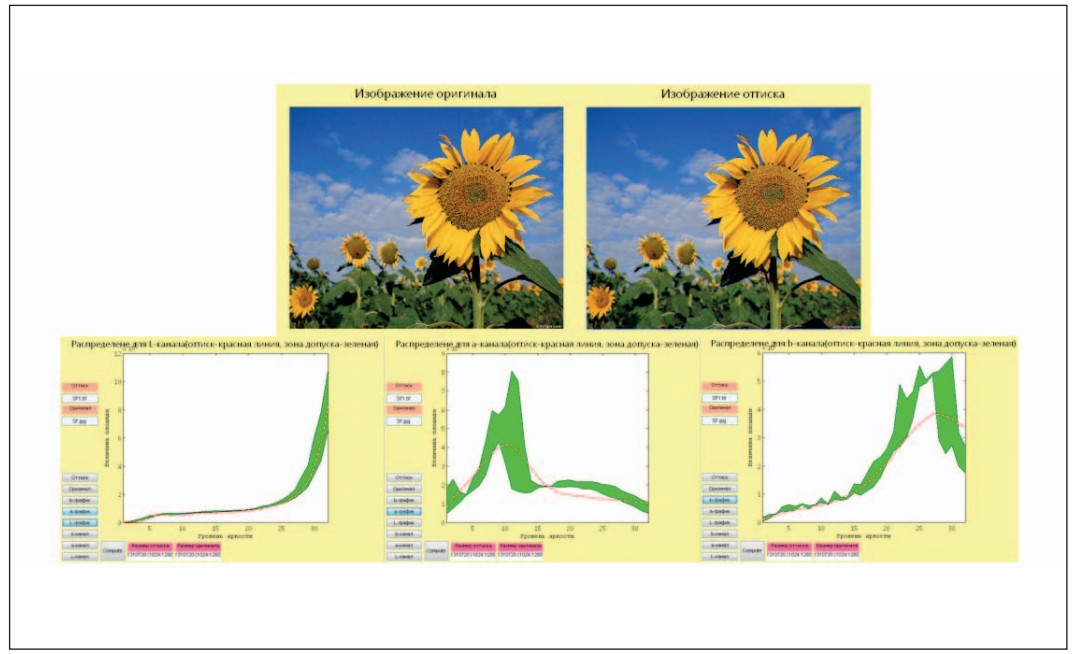

Figure 3.3: Comparison of data obtained from the experiment of the image with broken register of printing inks in the system CIELab for each channel.

Our experiments of changing the offset of printing plates lead to the conclusion: the change of the register of printing inks sharply changes the colorimetric characteristics of the print (value changes of the analyzed areas in the channels a and b), while it only slightly affects the overall perception of total brightness, which is in consistent with the visual perception process of the image by the human eye.

It should be also noted that the measurements using a scanner are far more accurate, since the size of the scanner crystals CCD is several orders smaller than the densitometer aperture, which is an advantage of the proposed method.

Usage of the digital model of the printed image enables to obtain generalized information about the investigated image quality. Among the advantages of the proposed method it should be also noted the fact that its use provides a pixel-map graded and chromatic matching of analyzed images.

So, the following result have been obtained: a specific indicator – the area occupied by sites with the same gradation characteristics, – precisely indicates the deviation of the image quality in the same way as human vision does it. During the experiments we obtain the dependencies that allow to characterize objectively the parameters of the image transformation and distortion. The result of this work is the conclusion that the quality control of printed matters using spatial modeling of print on the based on scanning the entire image area is possible and can be practically implemented.

4. Summary of results

The research has revealed that the analyzed parameter – the value of the area with equal half-tone characteristics – clearly indicates the deviations of qualitative characteristics of the image in the same manner as the human sight - the less is the value of the disturbing factor (color misconvergence, the difference of the screen ruling, differences between the form of the screen dot, dot gain), the less is the difference between the gained dependences. During the experiments it was also possible to gain the dependences that allow to characterize parameters of the transformation and the distortion on the analyzed images objectively. The result of the performed research is the conclusion that the offered method of quality control and identification of print is possible and can be practically realized [Dydyshko, 2008].

The check of the operation of the offered technique on the print produced with the use of various technological conditions (speed of printing, the quantity of paint transferred to pressing, combination of inks on pressing) has been performed. As a result, the coincidence of data on the quality of the investigated images gained with use of the offered technique, and meanings gained by means of traditional research techniques is obtained.

The developed technique can be applied to any existing printing technique, with little changes at the stage of reception of the digital model of the printing image, and with the correction of the interval of the legitimate value for the compared parameter.

5. Conclusions

On the basis of the analysis of technological features of the processes of quality surveillance of printed matter and of the questions connected with identification of the printing image, a pressing problem has been put and solved – a new technique for the control of conformity of the reproduction of the printing image to the confirmed sample has been developed. It was found that to arrive at the conclusion about the conformity of the reproduction of the printing image to the reference sample it is possible to use the value of half-tone and chromatic characteristics restricted by a certain ambit with fixed coordinates on the image plane. The control of the image by means of the values defined thereby is more in line with the visual perception process than the control of quantitative analysis of brightness or color coordinates on separate image elements [Dydyshko, 2009].

The way of segmentation of the printed image model on areas with equal half-tone and chromatic characteristics has been offered.

The way of calculating the zone of legitimate values for an investigated parameter has been proposed and experimentally verified.

The software product that performs complex data processing and visualization of research results, which are essential to draw the conclusion about the quality of the printing image, has been developed.

The experimental research of the influence of the basic technology factors on the accuracy of the estimation of the statistical parameters characterizing the quality of duplicating process has been performed.

The results of the research can be widely used in the production when manufacturing polygraphic products and for reengineering of production processes.

6. References

1. Dydyshko, S. Use 3-D modeling of a printed print for an analysis of quality / S. Dydyshko, A. Shevelev // Printing future days 2007/Institute for Print and Media Technology at Chemnitz University of Technology; редкол.: R. Baumann [и др.]. – Chemniz.
2. С. И. Дыдышко Методика криминалистического исследования объектов полиграфии на установление факта заимствования изображений (фрагментов изображений) / С.И. Дыдышко, Д.В. Липень, А.А. Шевелев; НИИКиСЭ Министерства юстиции Республики Беларусь. – Минск: Право и экономика, 2008.
3. Dydyshko, S. Use of digital modelling of the print for the estimation of quality of a press / S. Dydyshko, // Digital Fabrication 2008 /Institute Media Technology at Pittsburg University of Technology; редкол.: R. Mills [и др.]. – Pitsburg, 2008.
4. Dydyshko, S. Technique of estimation of quality of printing prints and diagnostics of process of reproduction by means of the offered technique. / «Innovation of publishing, printing and multimedia technologies 2009», – Kaunas, 2009

(first received: 31.03.2011)

Sergey Dydyshko

Belarus State University of Technology
Belarus, 220050,
Minsk, 13a,
Sverdlova str.

E-Mail:
S.Dydyshko@mail.ru

Sergey Gulyaev

Moscow State University of Printing Arts
127550 Russia,
Moscow, 2a,
Pryanishnikova str.

E-Mail:
dic@mgup.ru