

# The application of information technologies for color reproduction and technical system management in printing art production

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**Abstract.** The article develops the process of modeling color separation in the reproduction of graphic information in printing technology, shows the management of the technical system at each stage. With the use of information technology, this complex and multi-stage technological process of color conversion is carried out automatically, which does not allow showing the clarity of technological operations.

## 1 Introduction

To ensure the possibility of reproducing a full-color image using printing technology in the process of obtaining a reproduction, it is necessary to make a transition to a four-channel CMYK color space, using subtractive synthesis printing inks: cyan, magenta, yellow and black (key color, Kontur). This color space is not standard for a digital imaging system, where the three-channel RGB color space and its derivatives, such as HSB, HSI, are more often used. To switch to the CMYK space, a color management system (CMS) is used, based on hardware-independent PCS color spaces and a system of device profiles that take into account the peculiarities of color formation on a specific printing device. However, there are general principles of color formation, due to the subtractive synthesis system and the limitations of the amount of ink applied to the surface of the printed material, all together this is called autotypic synthesis. The conditions for autotypic synthesis are the transparency of paints, overlapping paints and the formation of an image from microdots of different size. The process of representing an image in a four-channel CMYK color space is called the separation process, and the process of dividing an image into microdots is the screening process. Color separation is carried out in the CMS system, and screening is carried out in special raster image processors (RIP). Both processes are carried out in digital form and there is no visual representation of how these processes are carried out and how

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changes made to the color separation and screening parameters will affect the final result. The only way to assess the effect of the described transformations is to carry out a digital color proofing by which the final result can be controlled, that does not allow us to understand the essence of the process and the influence of its individual stages. To understand and interpret the results obtained, a correct simulation at the stage of designing printing reproduction needed [1-9].

The purpose of the study is to simulate the process of color separation and create an algorithm that takes into account natural transformations, that makes it possible to implement and visually represent the management of a technical system at each stage of the process of reproduction of graphic information using modern information technologies. To achieve this goal, it is necessary to solve the following tasks:

- Modeling the process of color separation using information technologies;
- Carrying out measurements using the software environment and determining the distortions of obtaining information behind RGB color separation filters;
- Implementation of distortion correction for obtaining information behind RGB filters by the example of software modeling of an analog masking process.
- Modeling the process of screening and tone enhancement;
- Modeling of autotypic synthesis.

Research methods and tools. To solve the set tasks and achieve the final goal of the study, within the framework of this work, the capabilities of modern graphic editors, raster image processors, as well as methods for processing digital image information, successfully implemented in innovative technologies, were used.

With the transition from analog technologies for processing visual information to digital, the color separation process has become fully automated and, as a result, hidden. Previously, in relation to analog photography, this process was implemented by photographing a color image sequentially behind three color separation filters (blue, green and red) installed in front of the camera lens. Currently, the image is converted into digital form during the process of scanning it by digital equipment - a scanner or digital camera, where color separation filters are installed directly in front of the light-sensitive sensor.

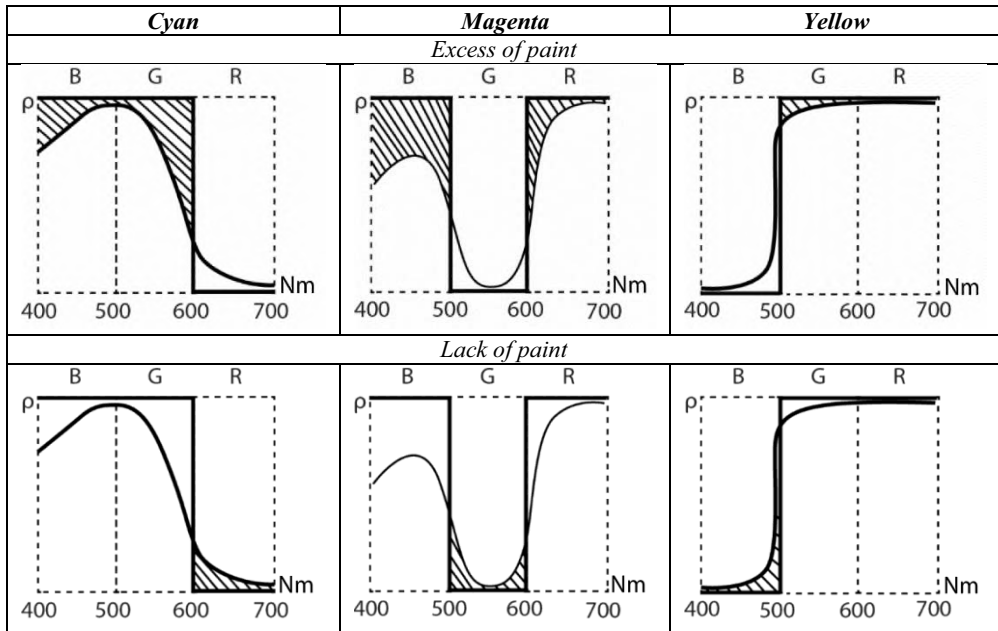
The process of color separation includes the following stages: analytical, transitional and synthesis stage. At the analytical stage, the original image is readout in three main zones of the visible range of the spectrum of electromagnetic radiation - blue, green, red. As a result, the readout image is divided into three channels of the RGB color space. Further, the image obtained behind the red filter will be used to form gradations of optical densities for cyan ink, behind the green color separation filter - for magenta ink, behind the blue - for yellow ink. At the analytical stage, phenomena inevitably arise that will further lead to incorrect reproduction of the color of the reproduced image.

Hypothetically, each subtractive synthesis paint should absorb part of the electromagnetic radiation in the only area of the visible spectrum. In this case, the distribution of the values of the spectral reflection coefficient of electromagnetic radiation  $\rho$  for paint should be characterized as presented in the graphs in table 1 (highlighted by a thick line). However, such distribution is possible only for the so-called ideal two-zone paints. Such paints do not exist in the nature as they are "model" colors.

If real paints are used, the spectral reflection curves have a different character. For example, a blue ink that should be fully reflected in the blue and green areas of the spectrum, actually has partial absorption in these areas. This leads to the fact that this paint stands out not only behind the red filter, but also partially behind the blue and green ones. Subsequently, at the stage of synthesis, magenta and yellow colors will lay on those places that were originally intended for blue. The same will happen for the other ones (tab. 1).

Thus, excessive absorption of real paints in those zones of the visible range of electromagnetic radiation, where it should not be, leads to the flaws of color separation, which are called distortions by excess paint. There is also another problem associated with the fact that excessive reflection of the colors in the absorption zones leads to a decrease in the gradient of the highlighted inks relative to the gradient of the black ink [10-15]. This defect of color-separation is called distortion due to lack of paint (tab. 1).

**Table 1.** Spectral characteristics of real paints

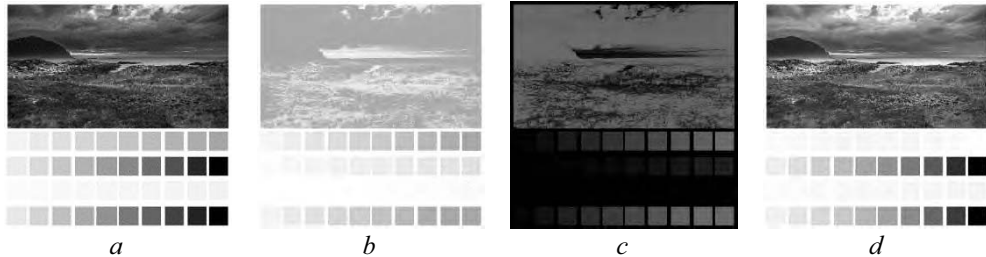


At the transitional stage, transformations are carried out that occur when registering a color separation image. Therefore, the main task that has to be solved at this stage is to eliminate those undesirable phenomena that arise at the analytical stage. At this stage, the screening operation is also carried out - the conversion of a halftone image into a binary micro-line image.

The final formation of color reproduction performed at the third stage - the stage of synthesis. In polygraphic reproduction, it is a printing of the combined color-separated images using subtractive synthesis paints on the printed material (paper, film, etc.). It is at the stage of obtaining the finished print that the distortions that have arisen at the analytical stage of the color separation process become obvious.

Elimination of distortions of the obtained information behind RGB color separation filters earlier, as applied to analog technologies, was performed using one-stage cross-photographic masking. The essence of this method is as follows: in the process of highlighting, for example, magenta paint behind a green color separation filter, a grayscale image is obtained, where the corresponding paint has gradation - it is easy to trace it if the original contains the necessary stepped scale (Fig. 1, a, scale second from the top). At the same time, it can be noted that in the resulting image the scale for blue paint also has gradation, which indicates a distortion of the first type (Fig. 1, a, the first scale from the top). Thus, it is necessary to achieve the elimination of gradation on this scale. To do this, behind a red filter (which ensures the selection of blue paint), a grayscale image is made,

which has a gradient corresponding to the gradient of unwanted paint in the green filter image - a mask (Fig. 1, b). In this case, the mask must have a reverse polarity (i.e., have an optical density distribution opposite to the original - Fig. 1, c). Combining the color separation image and the mask with each other gives the desired result - the gradation is preserved only on the magenta scale (Fig. 1, d). To correct a blue-filter image designed to isolate yellow ink, a decrease in the magenta scale gradient is necessary, so the mask is made behind a green color separation filter that provides magenta ink separation. The fundamentals of the one-step cross-photographic masking method are still being used in various digital algorithms for processing image information.



**Fig. 1.** The sequence of operations for elimination of distortions of obtaining information behind the green filter: a - the image obtained behind the green filter; b - an image obtained behind a red filter; b - mask; d - the result of combining the mask and the original image

Now the need to make masks disappears due to the fact that the elimination of the above-described distortions occurs due to the selection of compensating coefficients already at the stage of digital imaging behind the color separation filter located right in front of the sensor, depending on the passing ability of the color separation filter. Thus, if the process is considered on the example of Figure 1, stages b and d are bypassed. The main difficulty that arises at this stage is that previously, color separation distortions could be directly observed using analog technologies, but now the opportunity to observe intermediate stages of this process is lost and the process has become more complicated as a result.

To be able to form a visual example of displaying the intermediate stages of the color separation process, a simulator model is proposed that works according to the following algorithm, presented in Figure 2.

The presented algorithm includes the following stages:

1. Digital imaging the original image;
2. Conversion to CMYK polygraphic synthesis space;
3. Creation of multi-gradation scales to control the process of color separation and modeling of the triad of polygraphic synthesis paints;
4. Simulation of sequential digital imaging of the image behind the main filters: red, blue, green;
5. Measurement of the fields of the scales on the light (brightness) channel;
6. Construction of gradation characteristics;
7. Elimination of color separation distortions of each color channel by adjusting the gradation characteristics;
8. Translation of each color channel of the image into a bitmap with variability of parameters:
  - Output resolution;
  - Halftone screen Liniature;

- Signal modulation (AM halftone screen, FM halftone screen, hybrid halftone screen);
- Rotation angle of halftone screen;
- Shape of a raster dot.

9. Modeling tone gain is carried out according to the Sheberstov-Murray-Davis formula (1):

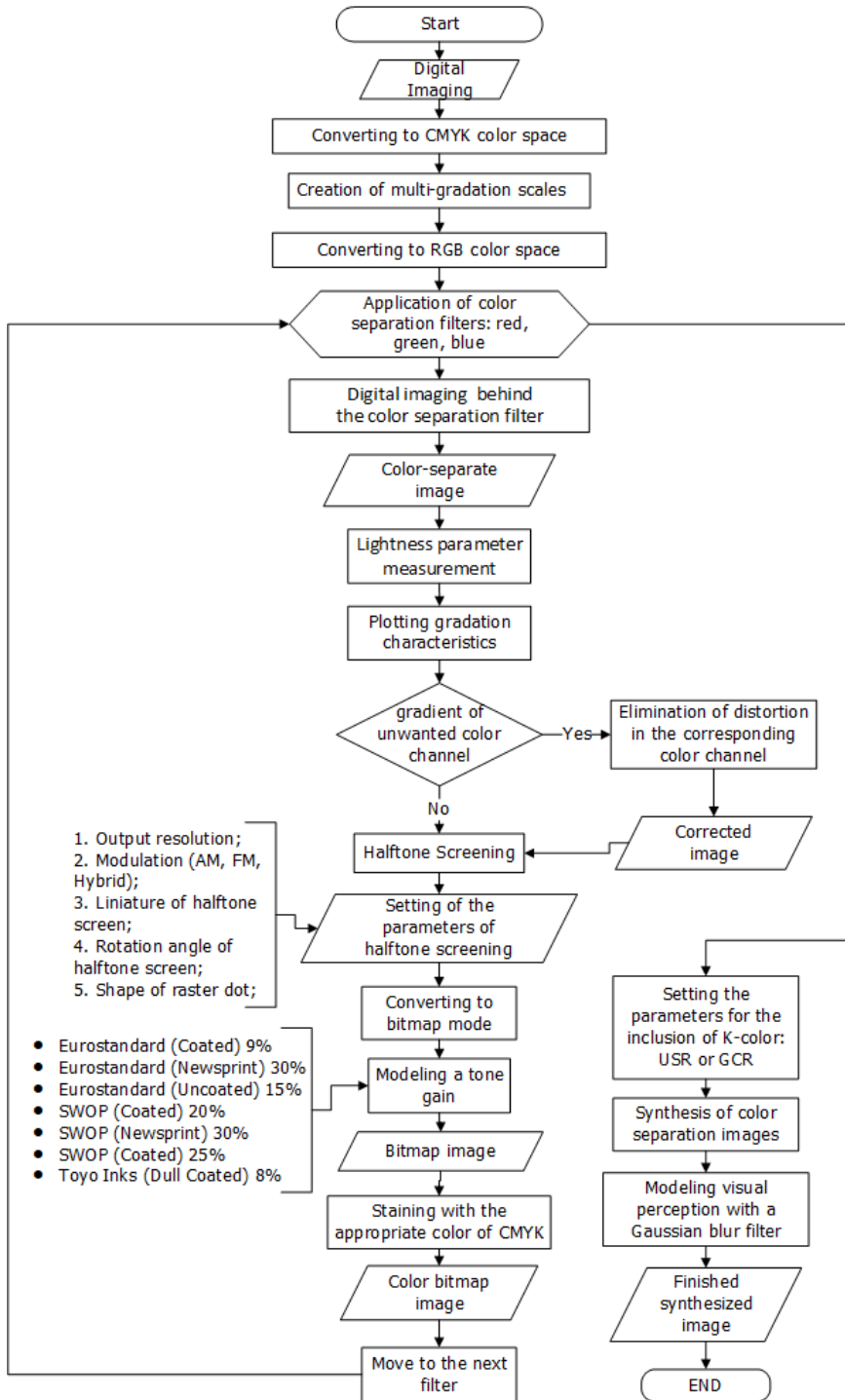
$$\Delta S = \frac{1 - 10^{-D_p}}{1 - 10^{-D_{pl}}} \quad (1)$$

where  $D_p$  is the optical density of a solid color;  $D_{pl}$  is the optical density of a printing surface; and  $\Delta S$  is a gain of an area of raster dot. Modeling tone amplification in the software environment means porosity of screening image divided by squares consisting of  $N \times N$  elements. The number of these elements changes by some value  $\Delta N$ ;

10. Coloring in colors of polygraphic synthesis;
11. Synthesis (combination);
12. Modeling visual perception using a Gaussian blur filter (2):

$$h(x, y) = e^{-\frac{x^2 + y^2}{2\sigma^2}} \quad (2)$$

where  $\sigma$  is the standard deviation,  $x, y$  are the image coordinates.



**Fig. 2.** Algorithm for modeling the color separation process when reproducing image information

## 2 Conclusions

With the advent of information technology, the process of processing visual information is more and more automated, but at the same time, basics of the process necessary for its deep understanding go out of frame. This article proposes an algorithm for modeling the color separation process, which clearly shows the emerging shortcomings in the reproduction of visual information in printing technology. This algorithm makes it possible to implement the management of the technical system at each stage of the reproductive process by visualizing the intermediate results of color separation. With the use of information technology, this complex and multi-stage technological process of color conversion is carried out automatically, which does not allow showing the clarity of technological operations.

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