Densitometric Characterization of Digital Peripheral Devices for the Hybrid Photographic Processes

Elena V. Konstantinova, Igor A. Rotakhin, and Catherine A. Sokolova
St.-Petersburg State University of Moving Picture and Television
St.-Petersburg, Russia

Abstract

Last years are characterized by increasing penetration of digital information registration methods in various domains of science and technical knowledge. Digital systems are very attractive because of their universality, flexibility, swift action, and simplicity of technical realization, better stability, accuracy, and reproduction quality in comparison with analog methods. Particularly, digital methods of writing, processing, and reproduction, widely spread in sphere of cinematography, television, and photography.

One of the main problems, which rise on working with digital methods of image processing, is characterization (or calibration) problem of input and output devices.

The sphere of our interest is a hybrid photographic technology,[1] which permits to print digital image, obtained by digital camera or scanner, on the silver halide photographic paper. There are many problems in this sphere; tuning and calibration of digital silver halide printing devices cause the main of them.

The elaboration of methods and calibration profiles for the hybrid photographic process with a stage of digital processing of an image is considered in this paper. Calibration curves were obtained by correlation of optical density behind the red, green, and blue filters (Densitometer Brumicro) and RGB data.

The new hypothesis about possibility to use RGB data instead of relative luminosity values in the referent conception of tone reproduction[2,3] was proposed during these experiments. It was done by comparison of calibration curves and relative luminosity function in the way of both comparison of linear interpolation correlation coefficients of analyzed data, and calculation of Fisher's criterion statistics by methods of analysis of variance.

The confirmation of the given hypothesis permits to realize a transition from calibration (characterization) to quality indexing of color photographic positives.

Introduction

The problem of evaluating the quality of photographic images from their visual perception has a very long history. The problem is crucial, because in our daily life, at least within the limits of amateur photography, each of us has to evaluate the quality of photographic prints. The reason that this problem is difficult is that visual quality is an unformalized, psychophysical concept, developed by each individual on the basis of a generalization of his previous experience.

In connection it is necessary to note one of the main problem under decision at last years. This problem consists of an estimation criteria development and methods realization for the tone and color reproduction parameters calculation for hybrid silver halide photographic systems with digital image processing.

Experimental

Primary goal of research is to obtain the calibration curves for translation of optical density values in the RGB values of brightness during scanning.

Object of research: photographic systems with digital image processing.

Such systems can be divided into four types, which differ by a principle of the devices choice for image transformation to the digital form conditionally. It can be shooting with the digital camera and the subsequent output of the image to photographic paper, scanning of a photographic negative, slide or a photocopy as seen in Figure 1.

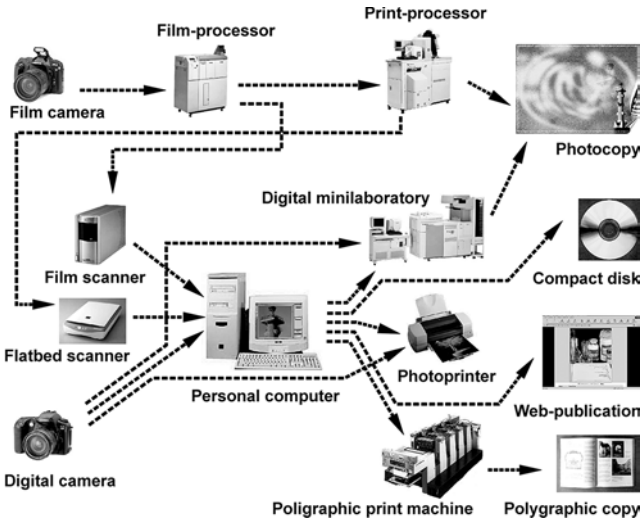

Figure 1. Photographic systems scheme with digital image processing.

For the image quality estimation of such hybrid process at each stage it is necessary to develop uniform criteria of an estimation, which adequately could be applied both for digital, and for a silver halide stage of process.

For this purpose we offer a method of densitometric calibration of scanners. Translation of optical density values (a silver halide stage) in RGB values (electronic stages of process) on calibration curve is stipulated.

Measurement of optical density and the control of tone reproduction were carried out with help of the hardware-software complex "Mirror"[3,4] developed by authors of the paper.

The received information acts in a database of tone reproduction parameters, and on its basis construction of calibration curves is made.

The means of brightness of digital image for each color channel (RGB model) were determined according to the indication on the "Info" panel (the standard procedure of the program Adobe Photoshop. The function relations $D^{RGB}=f(R, G, B)$ were plotted in graphic form by obtained means (Figure 2). Approximation of results was carried out by four functions: logarithmic, exponential, polynomial and a function $y=kx^a$. In each case the factor of correlation was calculated. Results have shown, that most adequately calibration curves are described by a $y=kx^a$ function.

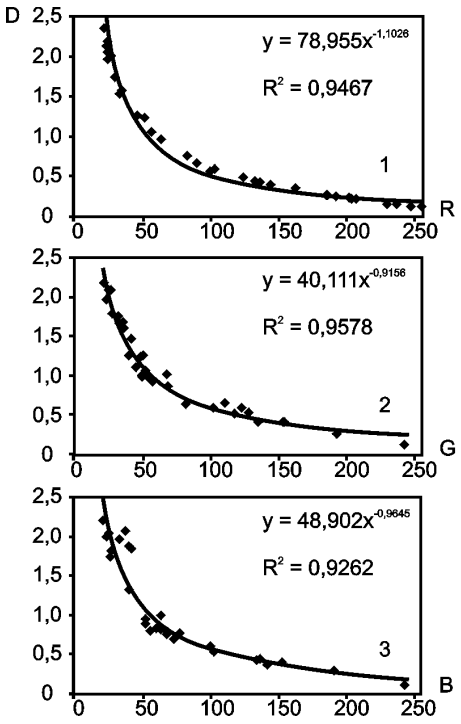

Figure 2. Calibration curves for converting RGB values into optical densities: 1-behind red filter, 2-behind green filter, 3-behind blue filter.

The database of tone-reproduction parameters in photographic systems with digital image processing was created on the basis of calibration curves.

The database information basis was build on the experimental results of the tone-reproduction estimation in through photographic process for cameras:
Canon F1, lens CANON LENS FD 50mm 1:1,4,
Nikon F4, lens AF NIKKOR 50mm 1:1,4,
Zenit 11, lens Helios 44 M 58mm 1:2,
Zenit 12, lens Helios 44 M -4 58mm 1:2.

Subsequent scanning negative image was applied. The film Kodak T-Max 100, T-Max 400, and developer D-76 were used in our experiments.

The standard gray scale (HIII-3) was used as test-object for taking photos. The negative photographic films were developed up to various average gradient values in the interval 0.55 - 0.90 for the definition of optimum development degree.

According to the technique, developed by us,[3,4] the curves of objective tone-reproduction have been constructed for all photoshooting and processing specified conditions.

At the same time the image quality was visually estimated up on simulated prints of the shooting objects (black-and-white picture, portrait, landscape etc).

Figure 3 shows the dependence of the general gradient and gradient of linear part of the curve on the development degree of negative photographic films. The nature of reproduction is basically defined by gradient of reproduction in half-tones (linear part of the objective tone-reproduction curve). At the best images the gradients of objective tone-reproduction in half-tones should be approximately 1.15 - 1.20,[5] and the general gradient should be close to 1. Figure 3 shows, that with processing photographic films up to average gradient 0.62, the maximal gradient of the curve linear part reaches only 1.0, and general gradient - 0.71. It testifies the contrast loss of the image and proves by the data of a visual estimation of image quality (photo 1 in the appendix 1).

The optimum results both from visual estimation point of view, and on the data of the analysis of curves, are attained with meanings of average gradient of a negative photographic film in an interval 0.80 - 0.85 (photo 2 in the appendix 1). The general gradient of tone-reproduction curve thus 0.90 - 1.05, and gradient in half-tones 1.10 - 1.25.

Figure 4 shows the dependence of the relation of a general gradient of a tone-reproduction curve to a gradient of a linear part on the value of the average gradient of negative photographic film, and figure 5 - dependence of this relation on a relative aperture lens and average gradient of negative photographic film is submitted. From the submitted results it is visible, that the best meanings (closest to 1) relations of a general gradient of a tone-reproduction curve to a gradient of linear part also are obtained at the values of the average gradient of negative photographic film 0.80 - 0.85. It means, that at the given development degree the least meaning of distortions with reproduction of shooting object brightness details in its photographic image has place.

With the further increase of the average gradient of negative photographic film the substantial growth of the gradient of linear part of the tone-reproduction curve is

observed (fig.3), and also essential reduction of the relation g_{gen}/g_{lp}. (fig.4,5). These data testifies to growth of contrast in half-tones with simultaneous loss of details in lights and shadows. The quality of the image is worsened (photo 3., appendix 1).

The submitted results convincingly confirm necessity of an establishment of different degrees of development for black-and-white still-picture films and movie films. The analysis of objective tone-reproduction curves allows to make conclusion, that the optimum meaning of average gradient of photographic films should be in an interval 0.80 - 0.85.

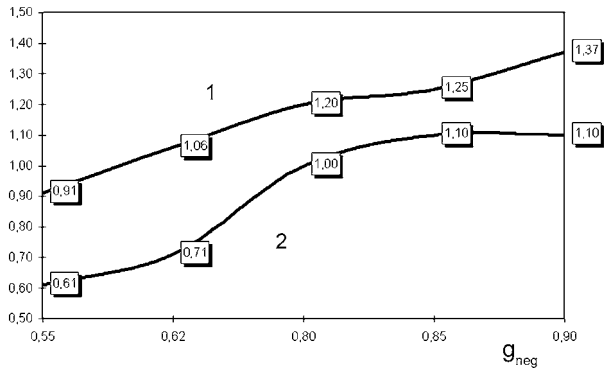

Figure 3. General gradient and gradient of the linear part of tone-reproduction curve versus development degree of negative photographic film. 1 – Gradient of a rectilinear site. 2 – General gradient of tone-reproduction curve.

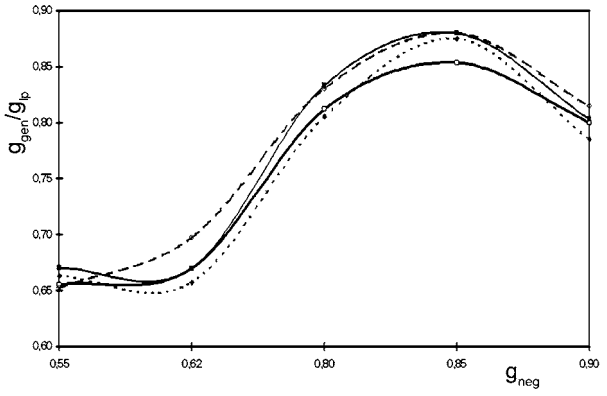

Figure 4. Relation of general gradient of the tone-reproduction curve to the gradient in half-tones versus mean gradient of negative photographic film: Nicon F4, Zenit 12, Zenit 11, Canon F1.

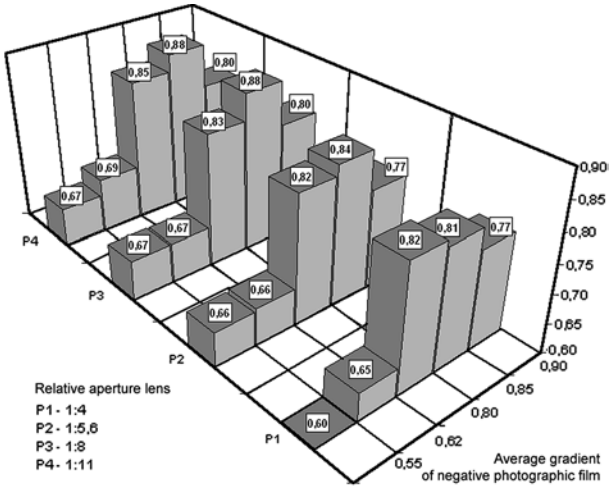

Figure 5. Relation of general gradient of the tone-reproduction curve to the gradient in half-tones versus values of the relative aperture lens and average gradient of negative photographic film

Appendix 1

photo 1.

photo 2.

photo 3.

References

1. Konstantinova E.V., Red'ko A.V., Filimonov R.P. Photographic systems with digital processing of an image: school book, *St.-Petersburg, edition of State University of Moving Picture and Television*, 2001.
2. V. A. Zernov, Photographic Sensiromelry, *Iskusstvo*, Moscow, 1980.
3. Konstantinova E.V., Red'ko A.V., Filimonov R.P. Checking the main assumptions of the referent concept of photographic tone reproduction. The Optical Society of America, *J.Opt.Technol.,* 68(6), 405-409 (June 2001).
4. Konstanlinova E.V., and Gukin A.N., "Program MIRROR for the visual selection of the conditions of photography" in *Collection of Scientific Transactions of NIKFI* (NIKFI, Moscow, 1996), pp. 128-132.
5. Konstantinova E.V., Grigoriev D.S. The statistic method of sensitometric test's results processing and estimating photographic parameters of movie and photo materials – The problems of development movie techniques and technology in *Collection of science articles SPIKiT*, part 5, SPb, 1995. p. 71-85
6. A.V. Red`ko The principles of photographic processes. SPb, *Lan*, 2000, p.94.

Biography

Elena Konstantinova received her B.C. degree in chemical sciences from the Institute of Cinema engineers at Leningrad in 1985 and a Ph.D. in technical sciences from the St.-Petersburg's state university of moving picture and television.

Since 1985 she has worked at cathedra of photography of St.-Petersburg's state university of moving picture and television as a lecturer.

Her work has primarily focused on the problems of tone and color reproduction in silver halide photography and digital photographic systems. She is a member of the IS&T.