Histogram Analyze as a Tool for Image Quality Estimation of Color Printouts

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Abstract

Defining quality parameters of color images is a current issue. Nowadays, there are developed international standards regarding color parameters. An important parameter is a comparison of color properties of images. Histogram analysis of saturation of primary colors on tested images is described. By means of PhotoShop or Photo Paint software the average saturation of primary RGB colors and lightness are defined. The proposed measuring method is a simple, inexpensive evaluation of saturation of color image quality.

Introduction

Estimation of image quality parameters is an important issue in image technology. Image quality parameters of color printouts has not been exactly defined and described in international standards, yet.

All the time investigations of color image quality are continued in many research centers in USA, Japan, Europe in the laboratories of manufacturers of printers and many commissions of ISO/IEC and other international organizations (for example in commission ISSO/IEC SC28).

Histogram analyze of color printouts is one method of image quality research, which is described in this paper.

Main Requirements of Image Quality (IQ) Researches

There are several main requirements for the research of image quality:

- objective, quantitative measurements, which on the other hand give consideration to subjective feelings of readers,
- exact definition and measurements of IQ parameters,
- exact determination of the IQ parameters definition by physical properties of color as well as quantitative determined of their value,
- exact determination of the measuring method, it's requirements and measuring instruments,
- simple and cheap measurement technique.

All this features has histogram analyze of color printouts.

Definition of Mean IQ Parameters of Color Printouts (Proposal)

There are proposed two means of IQ parameters: "Color Reproduction" (CR) and "Discriminations of color" (DC).

Color reproduction can be defined as color difference on tested image (sample) and on standard sample (original). Development sample and original one should be determined by international standard commission.

Quantitative value of CR can be determined by know parameter ΔE – Fig. 1, measured for example by spectrophotometer.

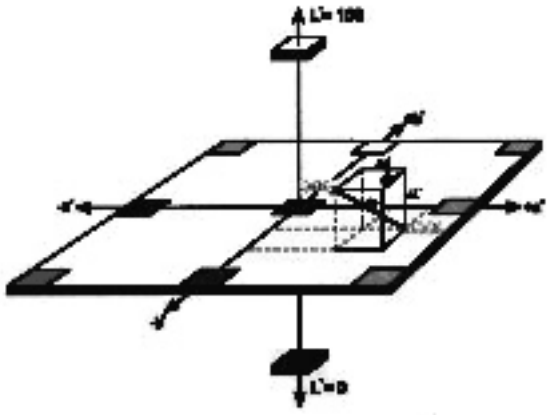

Figure 1. Graphical determine of ΔE

Unfortunately measurement by spectrophotometer is complicated and expensive to normal user, who could use convex maps are in teaching geography, history, math and another subjects.

Second possibility of measuring of CR is difference of average value of saturation on the sample and original printouts. Average saturation can be measured by the usage of the histogram. This measuring technique is simple and cheap.

Parameter discrimination of the color can be specified as difference in color saturation on neighboring samples – Fig. 2.

DC Parameter can be also defined as difference of the visual feeling of image on the sample and on the original by the observer eye. It is worth consideration that (subjective) feelings of the observer depends from the surrounding of tested image. Because of that good sample for DC determination is 16 neighboring rectangulars with gradually changeable color saturation of primary colors (by ISO /IEC 15775) – Fig. 3.

DC parameter can be as well estimated by visual compared inspection, which is very simple but subjective estimation of the observer.

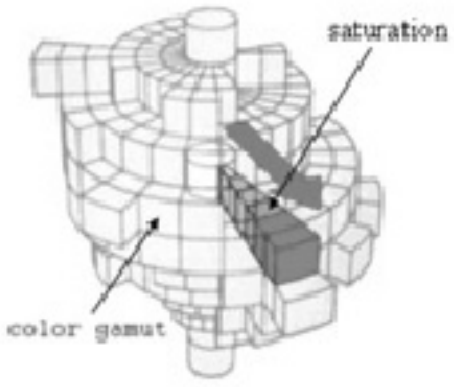

Figure 2. Graphical representation of saturation of color in color gamut

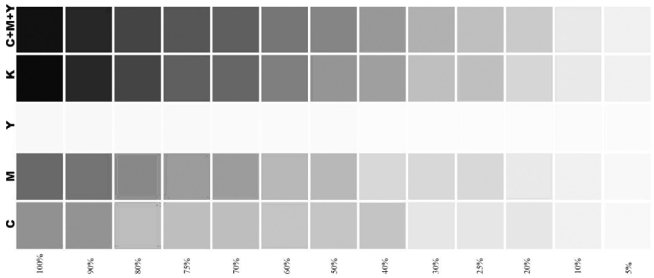

Figure 3. S*ample of various , gradual changed(16 steps) samples of saturation of primary colors (ISO/IEC 15775)*

Quantitative value of DC parameter can be measured by spectrophotometer as difference of ΔE on neighboring rectangular and determine as $\Delta E > V_{st}$. (Requirement value of V_{st} should be accepted by standardization commission). This measurement is complicated and expensive.

Other possibility of determination of DC value can be measurement of average saturation on neighboring samples, with the usage of histogram. This measuring technique is simple and cheap.

Measuring Method of Describing of Average Saturation by the Histogram Analyze

Saturation histogram of primary colors – Fig. 4 – presents number of pixels (vertical axis) in analyzed image. They have described saturation of color - (horizontal axis).

Brighter picture (less saturation) has histogram shifted to the left, darker picture (higher saturation) has histogram shifted to the right.

Histograms of the primary colors and of the lightness can be developed by software graphic programs such as: Photo Shop, Corel, Photo Paint. These programs developed of histograms (of primary colors RGB or CMYK and Lightness), and average value of saturation (with standard deviation and median) by definition and Fig. 5.

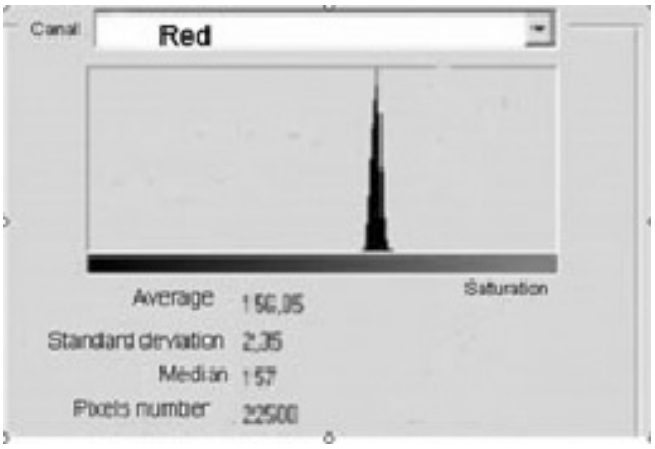

Figure 4. Histogram of saturation

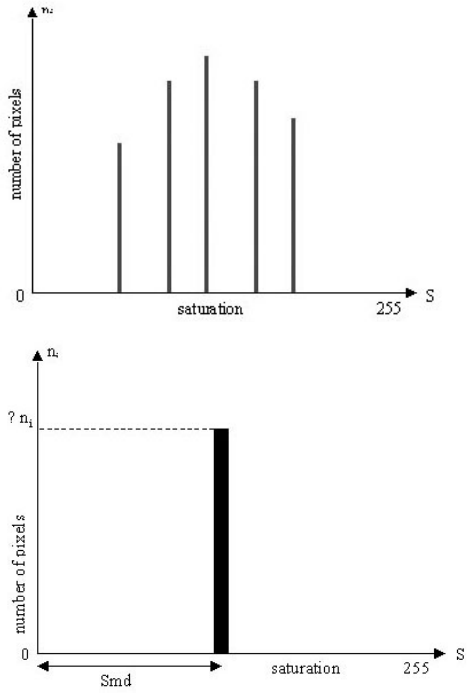

Figure 5. Graphical presentation of development of average saturation

$$S_{avR} = \frac{\sum n_i \cdot S_i}{\sum n_i}$$

$S_{av\,R}$ - average saturation of primary color red R
S_i - saturation of "i" point
$n_{i\_}$ - number points with saturation S_i

Histogram analyze can by developed in RGB and Lightness or CMYK and Lightness primary colors. It is proposed using RGB colors, because: eye sees image in RGB colors, scanner, display works in RGB too. Image quality parameters are analyzed using scanning, to same in RGB.

There are two main problems in histogram analyze. First is the fact that differences of average saturations are various, for example SavR1 (on one image) > SavR2 (on second image) and SavG1 < SavG2. Second one is the fact that saturation dependents from Lightness.

Therefore an universal general parameter called collective saturation SD (like as standard deviation) is proposed. The definition of the parameter is given by the equation:

$$SD=\sqrt{\left(S_{avRsam}-S_{avRorg}\right)^2+\left(S_{avGsam}-S_{avGorg}\right)^2+\left(S_{avBsam}-S_{avBorg}\right)^2+\left(S_{avLsam}-S_{avLorg}\right)^2}$$

where:

SD - collective saturation
$S_{av\ R\ sam}$ - average saturation of color R on the sample
$S_{av\ R\ org}$ - average saturation of color R on the original
$S_{av\ G\ sam}$ - average saturation of color G on the sample
$S_{av\ G\ org}$ - average saturation of color G on the original
$S_{av\ B\ sam}$ - average saturation of color B on the sample
$S_{av\ B\ org}$ - average saturation of color B on the original
$S_{av\ L\ sam}$ - average saturation of Lightness on the sample
$S_{av\ L\ org}$ - average saturation of Lightness on the original

SD parameter makes possible to compare saturation on the color images.

Recapitulated can corroborate: histogram analyze is a simple, cheap method of measurement of color image properties.

Measuring

Environment

- Input file: TIFF file of primary colors C; M; Y; K; C+M+Y; R;G;B
- Printouts from laser printer A,B,C,D
- Measuring ΔE on 100%C, 100%M, 100% Y, samples (measured by spectrophotometer SPECTROLINO GRETAG Macbeth),
- Analyze of average saturation on the same samples(using PhotoShop).

Results of measurement are presented in Table.1.

Table 1: Comprison of Average Saturation of the SD and Δ ELab Achieved by the Histogram Analyze (Measured by Spectrophotometer)

printer	A	B	C	D
Δ ELab	8,95	9,46	12,15	16,32
SD	32,17	35,87	50,85	75,20

Changes of the SD parameter are analogous to changes of ΔE. Analyze of average saturation is one of the tools for color image quality estimation.

References

1. BuczynskiL., "*Problems of IQ Parameters of Color Printouts"* presentation on the meeting CEN?BT/ TF 165 Remanufactures and compatible toner and inkjet cartridges, Brussels 2004

Author Biography

Ludwik Buczynski received his PhD degree in micromechanics from Warsaw University of Technology in 1972. Since 1963 he has worked in Micromechanics and Phonics Institute of Warsaw University of Technology and since 1986 in R&D Center Office Technique, PREBOT, Radom Poland. He is a member of IS&T, and since 1990 his main area of interests are computer peripherals devices and image quality investigations.