The Comparison of Photo Quality of Digital Photos from Different Digital Still Cameras

Ludwik Buczynski, Witold Jaszczuk, Jan Jedlinski, and Pawel Zackiewicz
Warsaw University of Technology
Warsaw, Poland

Abstract

Quantitative evaluation of "Photo Quality" (PQ) presents an important issue in research and in practice. Many developers of digital printers use the term "Photo Quality" to describe the quality of printed digital photos. The definition of the term is neither standardized nor established yet. Therefore its usage may often be misleading. In the preceding papers there had been a couple of proposals of PQ definition given, as well as the methods for its value determination. In the present paper we analyze the influence of various digital still cameras on the quality of their printouts. The printouts' parameters concerned were determined with accordance to ISO/IEC 13660 for monochromatic properties and working draft ISO/IEC/JTC1 SC28 for color, with the use of Gretag Macbeth SPECTROLINO spectrophotometer and Profilmaker 3.1. We present new corrected equations for PQ as well as the rationale behind them.

Introduction

Many manufacturers have developed dedicated printers for printing color images originating from digital still cameras (DSC). The quality of the prints is frequently claimed to be "photo quality". Strict and commonly accepted definition of this term does not exist yet, however. This undefined term may at times be misleading.

A proposition of a quantitative measure of "photo quality" as well as the methods for the determination of a value of the measure were presented in the preceding papers [1,2].

Many scientific efforts are aimed at the transmission of the colors of the original scene by digital photography. The objects of examinations include: DSCs' properties, the properties of CCD and CMOS imaging sensors utilized within the cameras, the particulars of color perception by human observer, [3] the impact of the inks and the papers used in color photo printing.[3,4,5] With regard to the assessment of the quality of printed photographs special interest present the publications dealing with color analysis of printed photographs, [7,8,9] consistency of their color features [3,6,7,8] and also on the progress in the DSCs' design.[4] The papers indicate extreme complexity of issues involved, especially the difficulty in separation and precise determination of the combined influences of particular features of a camera and the scene itself (properties of scene illumination; colorimetric and other characteristics of the imaging sensors; camera white balance; in-camera image file rendering; the kind and amount of compression applied to the output image files) on the color quality of the photographs obtained. Those may be viewed by an observer on CRT or another type of monitor, or projected on a screen by an optoelectronic projector, or printed on a paper. Every kind of display device may distort color in its own way.

Irrespective of the format of an image (file, CRT, screen projection, paper copy) subjective comparisons by observers seem at present to be unavoidable.

In our research as the scene to be photographed we used the hardcopy of the color target (master) provided in the form of the file by Minolta Research and Development Center, Toyokawa, Japan. The target had been printed by DeskJet printer HP 5550, on A4 Photo Glossy 170 paper with the use of MatchPrint technology. This same printer, with unchanged ink cartridges, was later used to obtain the photos to be assessed. We used four similar DSCs (here marked as A, B, C, D) from two manufacturers. The cameras were set up in their setups as identically as they permitted. Shots were taken under indirect unvarying illumination, carefully adjusted for uniformity, from photographers' halogen lamp. JPG files output by the cameras did not undergo any form of processing (e.g. by PhotoShop, Corel or the like).

Comparison Between the Output Files from Different Cameras

Minolta's target we used contained four stripes, each colored with another CMYK color, each stripe having the saturation stepped in 10% increments, from 0% to 100% (fig.1).

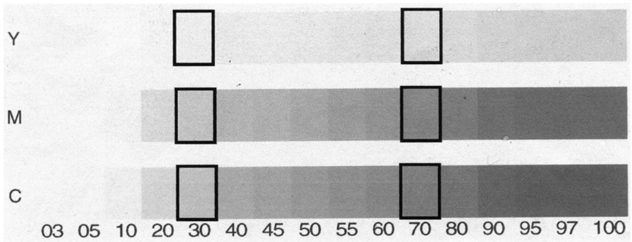

Figure 1. Tested color stripes C ,M, Y.

To compare between the four camera (A, B, C, D) output files we utilized PhotoShop 4.0, which enabled us to determine the values of Lab color space parameters of any selected element of the stripes, as well as any portion of the target image file. The values of Lab parameters from the cyan fields with 30% and 70% saturation for A, B, C, D cameras with the camera White Balance set for Auto, and set for Tungsten are given in table 1 and 2 respectively.

Table 1. Values of Lab for Auto White Balance

Cyan 70%				
Camera	**A**	**B**	**C**	**D**
L	75	72	73	72
a	-7	-9	-6	-9
b	-7	-20	-2	-3

Table 2. Values of Lab for Tungsten White Balance

Cyan 70%				
Camera	**A**	**B**	**C**	**D**
L	74	77	71	70
a	-15	-18	-6	-7
b	-27	-23	-30	-39

The differences between the L values for various cameras reach 5%, while differences between a and also b values for them exceed 50%. Similar magnitudes are the differences in Lab values for the rest of CMY colors taken at the fields of other saturation.

Measurements of Photo Quality Parameters

Values of the parameters which had been chosen to reflect linear features of the printouts from DCSs marked as A, B, C and D, that is "blurriness", "raggedness" and "contrast", as the area parameters "darkness" and "mottle" were chosen.

For color reproduction we had used the percent saturation of primary colors on the CMY color test stripes of the target found in the printouts. With the use of Gretag Macbeth SPECTROLINO spectrophotometer we had also measured the color differences ΔE between several fields of color test stripes of the printouts and the corresponding fields of the target.

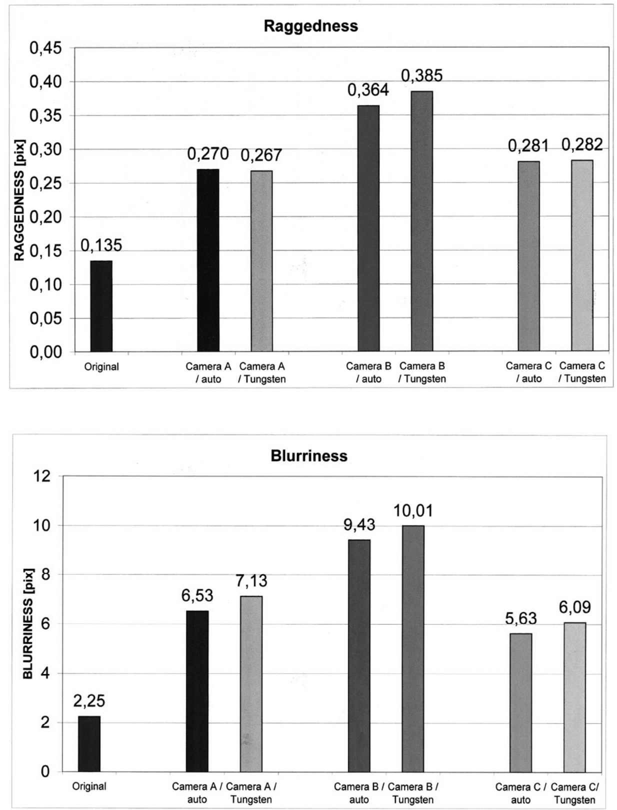

Figure 2. Linear parameters of Photo Quality

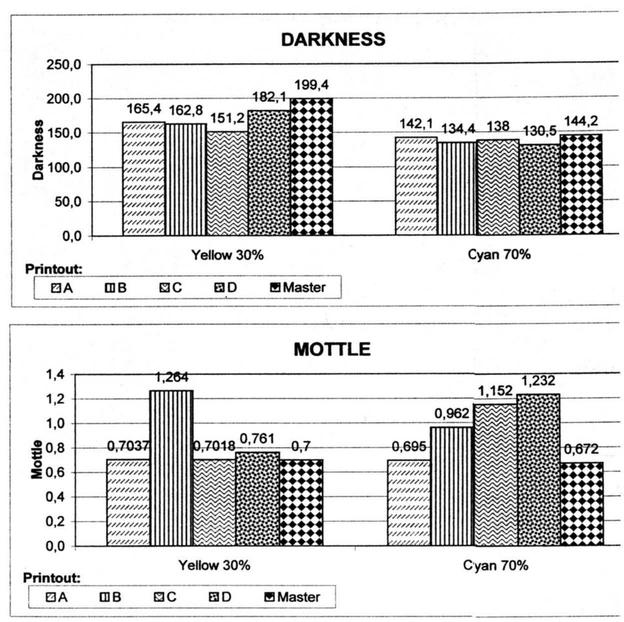

Figure 3. Area parameters of Photo Quality

Table 3. PQ parameters (Y30% and C70%)

Camera	LINE			AREA (for yellow 30%)		COLOUR SATURATION (for yellow saturation 30%)		
	BLURRINESS	RAGGEDNESS	CONTRAST	DARKNESS [%]	MOTTLE	C [%]	M [%]	Y [%]
A	6,533	0,270	0,528	64,86	0,704	99,92	95,73	79,41
B	9,432	0,364	0,414	63,84	1,264	98,75	98,98	93,29
C	5,629	0,281	0,452	59,29	0,702	100,00	93,73	69,88
D	-	-	-	71,41	0,761	100,00	89,80	78,67
0 Original	2,249	0,135	0,872	78,20	0,700	97,84	99,84	82,59

Measured Parameters

Camera	LINE			AREA (for cyan 70%)		COLOUR SATURATION (for cyan saturation 70%)		
	BLURRINESS	RAGGEDNESS	CONTRAST	DARKNESS [%]	MOTTLE	C [%]	M [%]	Y [%]
A	6,533	0,270	0,528	55,73	0,695	83,96	93,61	99,96
B	9,432	0,364	0,414	52,71	0,962	63,02	83,49	100,00
C	5,629	0,281	0,452	54,12	1,152	92,39	97,92	99,41
D	-	-	-	51,18	1,232	93,73	97,84	99,92
0 Original	2,249	0,135	0,872	56,55	0,672	49,92	79,84	100,00

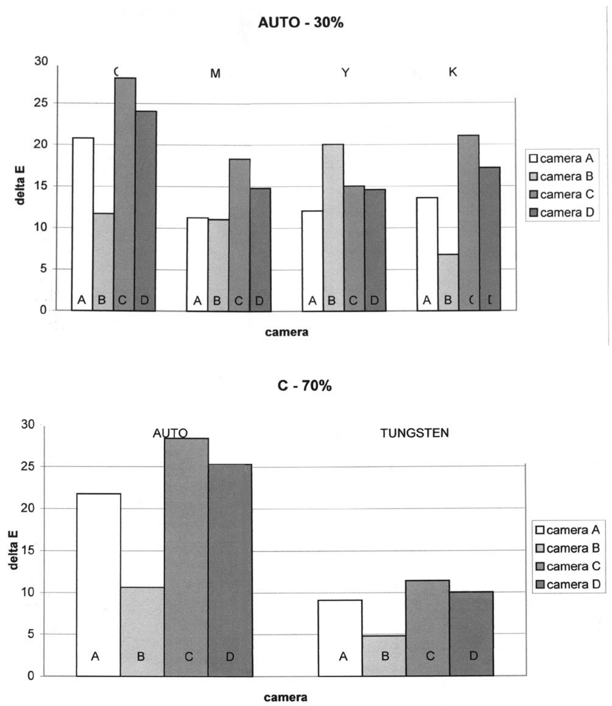

Figure 4. Color differences between the photos and the target

Our subjective judgement is that the color in the printouts does not satisfactorily agree with the color of the original color stripes in the target. We were unable to attain neutral white balance of printouts for any accessible white balance setting in the cameras. The printouts were biased towards cyan or yellow.

The values obtained for linear and area parameters (table 3 and fig.2, 3) reveal substantial differences attributable to the performance of particular camera and its setting.

The results of the measurements of the color parameters (table 3 and fig.4,) confirm the subjective opinion expressed above.

Photo Quality Index Analysis

According to the papers[1, 2] the determination of the Photo Quality Index value for the printed color image would consist in the determination of the values of the parameters, which describe both linear features of the printed output (blurriness; raggedness) and its area features (darkness; contrast; mottle) as well as the percent saturation of its CMY components. Those measurements made for the photographed target (the master) would yield the set of parameters P_0; while made for the printout obtained from the DSC under test would give the set of corresponding parameters P_i.

The Photo Quality Index (PQI) according to [1,2] is defined as:

$$PQ = = \sum W_i \,(P_i/P_0) \qquad (1)$$

where:

P_i, P_0 - as defined above,
W_i - factor of significance (weight) assigned to an i-th parameter.

The definitions of particular parameters P and the methods for their determination are given in the recommended international standard ISO/IEC 13660. The assumed draft values for Wi factors given below are based on the general knowledge of the techniques utilized in color photos printing.

The values adopted for W_i factors are as follows:

significance factor for "blurriness" W_b = 0,13
significance factor for "raggedness" W_r = 0,13
significance factor for "darkness" W_d = 0,10
significance factor for "contrast" W_c = 0,12

significance factor for "mottle" W_m = 0,10
significance factor for "cyan" W_{cy} = 0,14
significance factor for "magenta" W_{ma} = 0,14
significance factor for "yellow" W_y = 0,14

Conforming to the theory of multicriterial evaluation $\sum W_i=1$.

A flaw in the proposition (1) consists in that some P_i parameters (determined according to ISO/IEC 13660) may assume the values $P_i >= P_0$, which indicates poorer quality in those particular aspects (e.g. the blurriness, the raggedness, mottle). However other parameters, such as the saturation of CMY components of color test stripes, may deviate in both directions from the correct value of P_0 and the deviations may be significant, as we indicate earlier in this paper.

Therefore we propose that PQI for the former parameters be defined as

$$PQI_1 = \sum (P_0/P_i - 1) W_i \quad (2)$$

Here the smaller value of PQI, within (0,1), the better the quality of the photo.

For the latter parameters (CMY saturations) we propose that PQI be defined as

$$PQI_2 = \sqrt{\sum \left(\frac{P_i - P_0}{P_0}\right)^2} \quad (3)$$

Here again smaller PQI_2 values correspond to better photos. The authors believe that further work should concentrate on the selection of the parameters to be included in both PQI_1 and PQI_2. We also think that an attempt to develop a single criterion combining both indexes (2) and (3) does not seem sensible.

References

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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.