The New Tone Evaluation for the Digital Photography System Using Color Stair Chart and Color Space Values

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Abstract

In the any photography systems, the tone reproduction on the outputs is the most essential function. In the traditional silver halide analog photography, the tonal characteristics of the system is evaluated by camera-through sensitometry. That quality depends mainly on the medium and its developing process and the contribution of camera is not important factor to that quality. In the electronic digital photography, the tone characteristics will be evaluated by similar method to it, however the image processing function in the digital steel camera (DSC) induces the remarkable effect to that quality. The career of photo-image in the system is image data and it is more definite and detectable than the case of analog photography. This paper proposes a novel method to evaluate the tonal characteristics of the digital photography system with the online procedure.

Introduction

On the camera-through sensitometry for the traditional analog photography, the original tonal–information was introduced by camera shooting of stepwise optical density tablet. The step density tablet is shot by camera under the specific illumination. After the development of the exposed film, the film shows the reproduced stepwise pattern indicating the reverse density change. The density of the reproduction is measured by densitometer.

The tone curve of developed tablet is plotted with relation of density and input photo-energy in logarithm scale. The tone reproduction is estimated by comparison of slope and shape of both curves for the original and the reproduction.

In the current digital photography, the same principle of the camera-through sensitometry is available. The distinc-tive feature of the digital photography is that the input image information is carried by image date divided in 256 or higher rate and each datum is discrete and controllable. Thus the input original and the reproduced output images for the evaluation must be analyzed by more accurate factor than the density. The color space values for the reproduction is more exact than optical density.

The authors have been studying the tone reproduction of digital photography system.[1] This paper proposes the on-line evaluation of the tonal characteristics of digital photography system using the 8 bits linear lightness color step charts and colorimetric analyses of camera-out tonal image data for reproduction. The on-line evaluation showed the more definite characteristics than that obtained by colorimetric measurement of the reproduced chart image on the output print.

Analytical Procedure

In this work the key devices were the stepwise print charts showing the linear lightness (L*) and the high quality digital steel cameras (DSC) for the professional use.

The charts were the home-made original prints for the camera-through sensitometry. The magenta chart images were printed by thermal dye transfer printer, Sony UP-D70, on the A4 and the smaller size photo-papers and white opaque films. The thermal dye transfer printer is one of the best equipment to print the reproductions showing the perfect linear density change of 8 bits, 256 level.[2]

Figure 1 shows the patterns of the 8 bits linear lightness color step charts.

The basic chart patterns are produced by same concept as that reported in the former paper.[3] The arrangement of the chart pattern was as follows; 1) divide a print into 16 sections and assign 16 groups of serial printing level individually, 2) divide each section into two part, the left side printed by constant (16X)th level datum and the rest of right side was vertically divided into 16 patches and printed by 16[16(X-1)]th to 16[16(X-1)+16] level data.

Figure 2 shows the reproductions of two charts and Fig. 3 shows the relations between lightness and data level for the two type magenta charts. The linear lightness conditions for the 256 individual patches were assembled by PC using of Adobe Photoshop software. The linear lightness changes were realized in the phase of reflection and transmission on the paper and the film base print media, respectively.

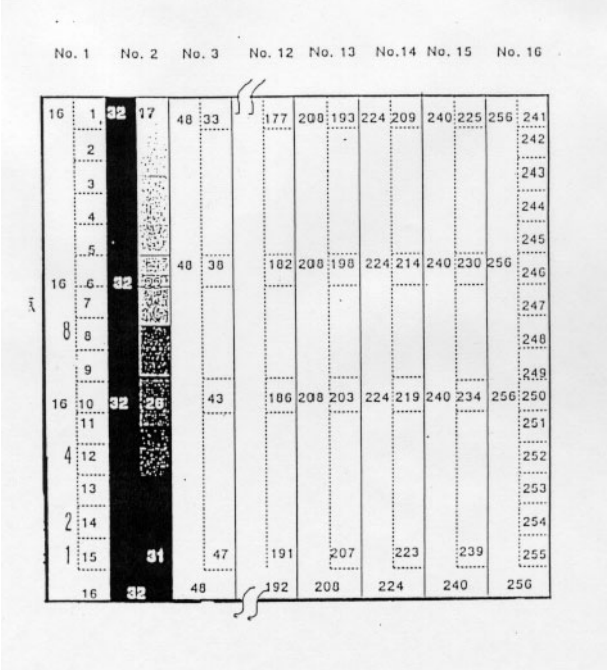

Figure 1. The pattern of the 8 bits linear lightness chart

Reflective chart Transmission chart

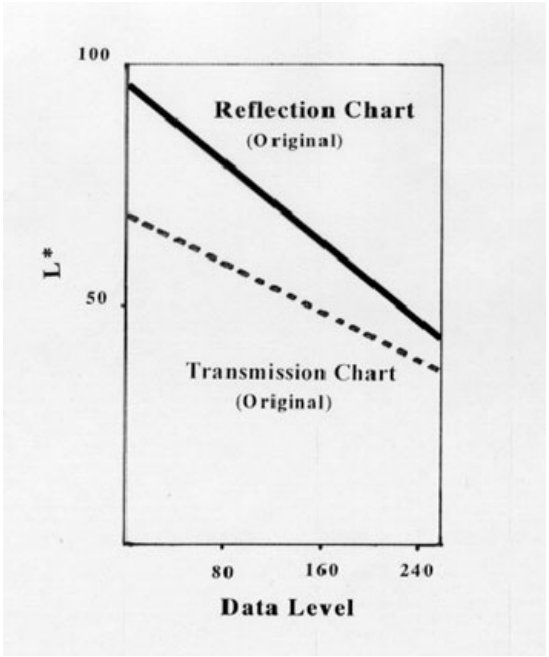

Figure 2. Reproductions of reflective and transmission charts.

Figure 4 illustrates the procedure for the analysis.

In the input stage, the charts were illuminated by light of D50 fluorescent lamp. The directions of illumination were front and back for the reflective paper-base and the transmission film-base targets, respectively. The cameras were the three DSCs having the high density CCD or CMOS imagers of Sony ST-5, Nikon D-1 and Canon D-60.

Before shooting the target, the white balance calibration was done to take the illuminated white base paper or opaque film. The exposure rate controlled by shutter speed of reflective paper and transmission film charts and iris of DSC determined as the detective lightness (L*) level of the above calibration white planes.

The condition of output image data from the individual DSC was the raw data formatted by each camera system and their color space conditions were calibrated by the s-RGB system.

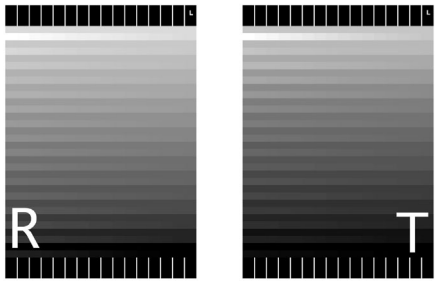

Figure 3. The relation of lightness and input data level

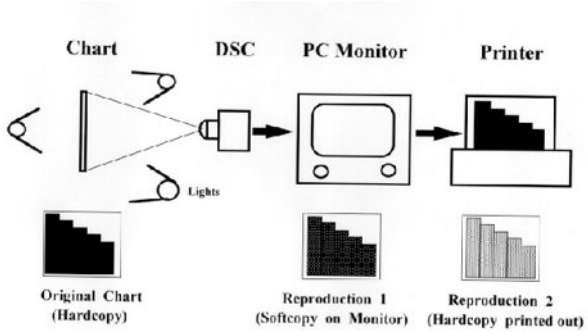

Figure 4. The procedure of the tonal characteristic analysis

After shooting the target, the image data of chart was first displayed on the personal computer, PC monitor using the Photo-shop software and then checked the colorimetric values of CIELAB, L*a*b* (1976) for individual patches on the reproduction of the chart image. This is the on-line procedure named as the "Soft-copy Evaluation".

The relation of lightness, L* colorimetric value and the input image data level suggested the tone characteristics of individual DSC. The qualitative discussion was available to compare the curves for various DSCs.

Then the image data was supplied to the above mentioned digital color printer and the reproductions were printed on the photo-paper type receiver in the same style hardcopy as the paper type original chart. On the reproduction, the colorimetric values of the same CIELAB values measured by contact colorimeter, Macbeth Spectro-Lino. This procedure named as the "Hardcopy Evaluation".

The colorimetric evaluations were done by curves between lightness (L*) and image data level.

Results and Discussion

The discussion was done to analyze the relation of lightness and data level on the original and reproduced chart images displayed on the PC monitor and printed hardcopies.

"Softcopy Evaluation"

The calibrated RGB color space values are able to convert to XYZ values and then to turn to L*a*b* values. In this work, the output color image data from DSC was converted to the sRGB format and the calibrated RGB color spaces value was generated. The next conversions of them to XYZ and further to L*a*b* values are calculated by the Photoshop software in the PC. The representative color L* values for every 16th patches of the reproduced were plotted on the graph of L* and image data level.

Figure 5 shows the curves of the three camera output data for the reflective and transmission chart images on the PC monitor. In the curves for the reflective chart, all curves showed linear to the input data level. Among the three curves, the curve for D-1shows the most steep and that of ST-5 is gentle. The results of the transmit chart, three curves for all DSCs was not linear and partly rose. Moreover there are no difference between the curves for ST-5 and D-60.

In the Soft-copy Evaluation, the curve for the original chart could not plot on the same coordinate because of the different L* measurements. The curves for the reflective charts suggest the qualitative comparison of results of three DSCs is available. The curve for ST-5 shows that it has the highest contrast gradation and that of D-1shows the lowest soft gradation. The comparison is only qualitative because there was no standard curve for the quantitative discussion.

"Hardcopy Evaluation"

Figure 6 shows the L* change of the reproduced hardcopies printed by output data from DSCs after the shootings. In this analysis, the L*values for the all specimen were measured by contact type colorimeter including the original chart. The all curves for reproductions of both type charts were linear even in the results of transmission chart. The order of slopes for the three DSC is the same as the results of Softcopy Evaluation. The difference was the more dull change to compare with the results of Softcopy Evaluation. The printing process thought to make dull the difference.

In the case of the reflective chart, the curve for the original can insert in the same graph by the measurement.

The slope for the original chart is linear thus the gentle curves for three DSCs suggest that the tone characteristics of those cameras will be gentle. The dull difference for the slopes for the hardcopy reproduction suggest that the gamma for the UPD70 printer looks to be low. on the output hardcopies.

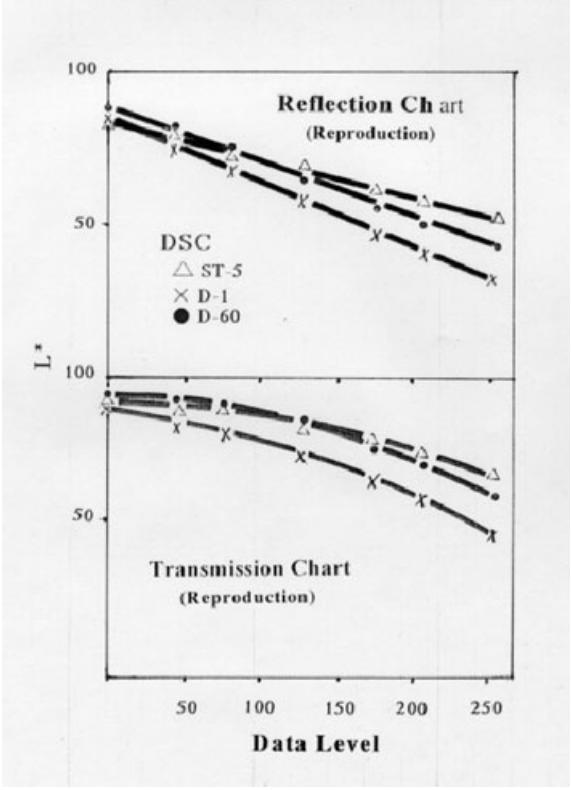

Figure 5. The L value change on the reproduced chart images on the PC monitor.*

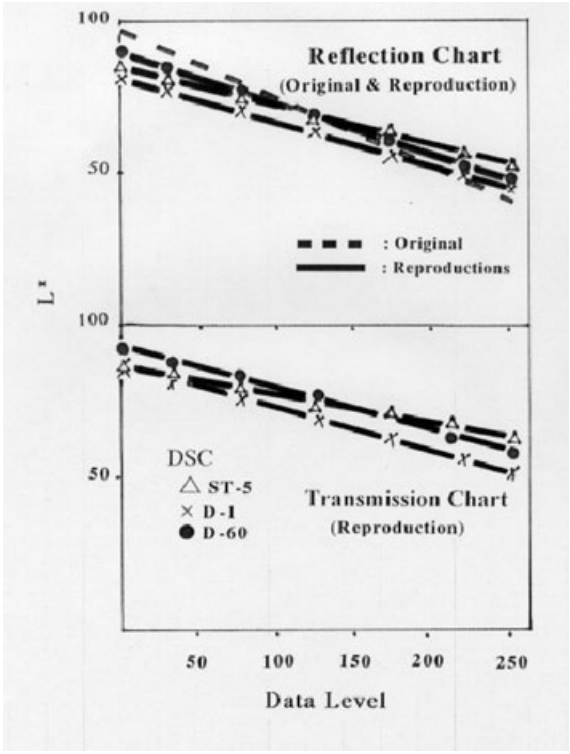

Figure 6. L value change for the reproduced chart images.*

Summary

The colorimetric evaluations were done by curves between lightness (L*) and image data level. The most curves were linear both in the Softcopy and Hardcopy evaluations. The steeper slope of curve for the reproduction than that for the original meant that the system showed the higher contrast, The more gentle slope suggested that the system showing the soft gradation. The comparison of slopes from the original and the reproduction suggests the tonal condition of systems.

The "Softcopy Evaluation" is the direct and PC driven analysis. The introduction of the standard calibration data based on the original chart will be invite better usefulness. The further investigation of the colorimetric analysis of the individual patches on the reproduced chart image will introduce more detailed discussion.

References

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Biography

Shin Ohno received his B.S. and Dr. Eng. degrees in Imaging Science from Chiba Univ. and Tokyo Inst. Tech. in 1962 and 1979 , respectively. In 1962 he has entered the Technical Research labs. NHK as a research associate. In 1989, he entered Electronic Photography Division, Sony Corporation as the chief engineer, In 2000, he entered Photography School, Tokyo Institute of Polytechnics as the professor. He is the executive member of IS&T, ISJ and SPSTJ. He is one of the pioneer of digital photography and also the founder of PICS Conference in IS&T.