 

# A Standard Portrait Image and Image Quality Assessment

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## Introduction

With the advance of computer technology, opportunities to observe images in various forms such as hardcopies and softcopies have been tremendously increased. Eventually, requirements to obtain color-appearance match between images displayed by various media under a variety of viewing conditions have become one of the important issues. To fulfill such requirements, CIE, ICC, and other organizations are developing methods to compensate the effect of different viewing conditions or those to map colors optimally for images across disparate media having different color gamut.

In such studies, new models or algorithms are usually evaluated by visual assessment based on psychophysical experiments. In such psychophysical experiments, stress upon each observer should be minimized in addition to accurate and stable results. In order to derive statistically reliable results, a scrupulous experimental setup involving a sufficient number of observers is required.[1,2] This usually results in time- and labor-consuming experiments. Therefore, even in the case of designing digital imaging systems, it is of great importance to investigate methodology for psychophysical experiments so that reliable and stable results can be obtained with minimum stress upon observers.

This paper is submitted as the first report of a project "Preparation of Standard Portrait Images and Study on Image Quality Assessment", which is aimed to derive and establish an experimental guideline for image quality evaluation. Especially, there is a strong demand to standardize an image with which psychophysical experiments are conducted between cross-media under a variety of conditions. The consideration on such standard image and its preparation procedures will be described. Then, the results of the psychophysical experiments based on the standard image will be discussed also.

## A Standard Image

### Preparation of a Standard Image

First of all, it is important to decide standard image for a visual assessment based on psychophysical experiment. For example, factors such as an image composition, a subject and a color cast are the examples that may affect the results of visual assessment significantly. So, to minimize an unwanted bias toward psychophysical experiments, possible important requirements for establishing a standard image are as follows;

1. Choose a model whose skin tone is close to that of a typical Japanese based on spectral reflectance.
2. Choose neutral gray for both clothes and background to avoid unwanted cast on skin tone and to remove an unwanted bias for visual assessment.
3. Shoot a bust size portrait from the right front of a model so that the facial part of the image is reproduced in an appropriate image size for visual assessment.
4. Camera apparatuses are those most widely used in professional portrait studios.
5. Adjust the lighting conditions for those of typical studio portrait, where a relatively soft lighting with illumination ratio of 1:2 is used to avoid dark shadows.
6. Select professional use 4 × 5" photographic films, which can be applicable to provide excellent image quality in sharpness and graininess.

After taking pictures to fulfill the conditions above, then a 2L size photographic print was made by using a typical optical printer. Skillful operators optimized density and color balance during print works. The apparatuses and materials used in the experiment are listed in Table 1. The printed image is illustrated in Fig. 1.

**Table 1 Apparatuses and photographic materials used for the preparation of a standard portrait image.**

| | |
|---|---|
| Camera and lens | Sinar P 4×5, Fujinon 250mm F:6.3 |
| Strobe | Photona PH 2501× 3 with umbrellas |
| Shooting film | Fujicolor NS 160 (a color negative film) |
| Photographic color paper | Fujicolor Paper FA-P |

### Preparation of a Digital File

It is useful if a standard digital file, from which the standard image can be reproduced, is reproducible for the future experiments. To reply such demand, the workflow of preparing a standard digital file is shown in Fig. 2. To

 

minimize image degradation, a drum scanner capable of 12bits depth per color was used to read the reflection print image. For each of pixels, the integral spectral densities were calculated through a prepared conversion table. Since the standard illuminant for the color space defined by ITR-R BT.709-2[3] is D65, CIELAB values under D65 were derived from the integral densities. Finally those values were converted to sRGB[4,5] and a digital file conformed to TIFF6.0 format was created.

*Figure 1. A standard image employed in this study.*

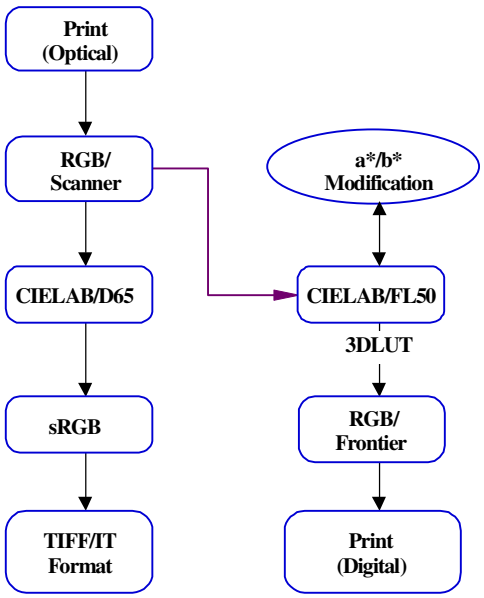


*Figure 2. Workflow of preparing a standard digital file.*

## Psychophysical Experiment

### Preparation of Prints for Psychophysical Experiments

Photographic prints for visual assessment were prepared with a digital laser photo-printer 'Frontier'.[6] This is because the present digital file is produced based on the original reflection print of a professional portrait, and this gives us a reliable anchor point for further psychophysical experiments.

Modification of skin tone of the portrait image was carried out by changing hue of skin area included in the image by a constant amount of a* and b* in CIELAB color space. By setting a unit color change equals to ΔEab* = 2, a total of 25 prints were prepared as shown in Fig. 3. The accuracy of the prints are confirmed by measuring a mean color difference less than ΔEab* = 0.2 .

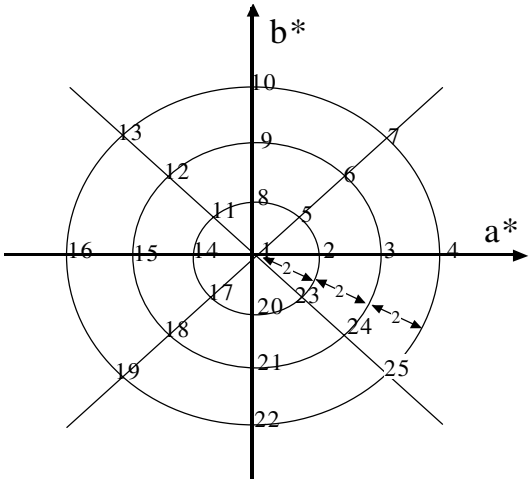


*Figure 3. Skin tone is modified as shown in this CIELAB diagram.*

### Experimental Design

The distribution of preferable skin tone is investigated in CIELAB color space by performing psychophysical experiments followed by the data analysis as follows.

## Setup

**Observers:** Twenty observers participated in the experiment. They were all male, ranged in age from 25 to 50, and had skillful at evaluating image quality. All the observers had normal color vision as evaluated by Ishihara plates.

**Viewing conditions:** Viewing conditions are those specified in ISO3664[7] wherever possible, however, in this experiment, fluorescent lamps for color evaluation by Toshiba were used. Illuminance on the print surface was adjusted to 1500lx and ambient brightness was set to that of an average indoor lighting. The prints were mounted on spectrally nonselective 18% gray cards.

 

**Psychophysical task:** After observation of each of prints for 5 seconds, each observer was asked to classify it into one of 4 categories (good, fair, acceptable, and unacceptable). Each observer was encouraged to do this task twice on different days.

## Data Analysis

In this experiment, to analyze data, we adapted a method known as 'the smaller the better signal to noise ratio' (Hereinafter, abbreviated as S-B S/N)[8] of quality engineering. It is known that there exist several methods well-known to derive a quantitative scale from the categorized data.[9] Taking an average for each of categorized data is the simplest way. A method by calculating Z score and derive each of distances between categories is typical one. The reasons for adopting S-B S/N analysis are as follows;

(a) Average values can not reflect on how the data are distributed among each of categories.
(b) The analysis based on Z scores assumes that a frequency distribution of judgement is to be Gaussian, which is not always meet the case especially when a number of observers participated in the experiments is limited.

S-B S/N is defined as an overall scale value, which is thought to be ideal especially when the variance of the data is small.

In this study, the S-B S/N is defined as follows,

$$S\text{-}B\ S/N = -10\ Log\{(Point^2)/the\ number\ of\ subjects\}\ in\ dB\ unit$$

where, Point = 0 for 'good', 1 for 'fair', 2 for 'acceptable', and 3 for 'unacceptable'.

Further, each category is assumed in terms of S-B S/N as follows.

- The categorical boundary between 'fair' and 'acceptable' = the S-B S/N value for all the judgements being 'fair', i.e.,

$$-10\ Log\{(1^2 \times n)/n\} = -10Log\ (1) = 0\ (dB).$$

- The categorical boundary between 'acceptable' and 'unacceptable' = the S-B S/N value for all the judgements being 'acceptable', i.e.,

$$-10\ Log\{(2^2 \times n)/n\} = -10Log\ (4) = -6\ (dB).$$

**Table 2 Psychophysical data**

| Category | Number of Samples included | Sample # |
|---|---|---|
| Fair - Good | 3 | 1, 20, 23 |
| acceptable | 6 | 2, 5, 8, 17, 21 |
| unacceptable | 16 | The remainder |

## Results

### Psychophysical Data

The S-B S/N values are shown in Fig. 4 and tabulated in Table 2. It is found from Fig. 5 that the sample #23 is evaluated as the most preferable one and considered as about 1.3 times (equivalent to 2dB) higher compared with the standard print (#1).

The figures show obtained S-B S/N values.

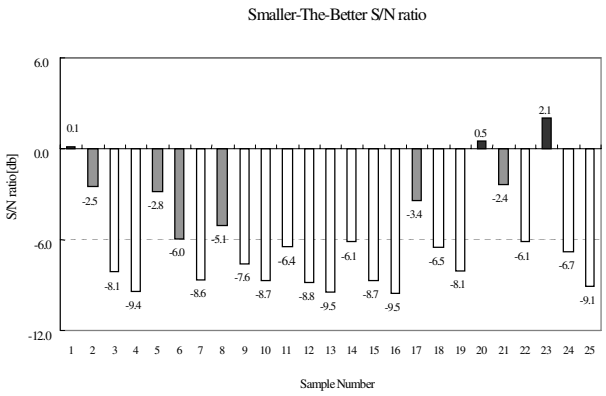


*Figure 4. The results of psychophysical experiments.*

### Preferable Skin Tone

The preferable skin tones are determined by investigating the relationships between psychophysical scale values and the average CIELAB values of skin tone for each of samples. The skin tone in the sample image includes forehead, cheek, chest and neck and we took an average of them for each of samples. Fig. 5 depicts the results, in which two contour lines are corresponding to S/N = 0 and –6db respectively.

In the figure, the region judged as good is demonstrated by a circle with a diameter of about 2.5ΔEab* centered at a*=18, b*=22. This center is slightly shifted from the point representing the standard print (#1) towards magenta direction. The acceptable region is shown as an ellipse with a diameter of about 5ΔEab* elongated along orange-hue direction. These results agree quite well with our experiences over many years.

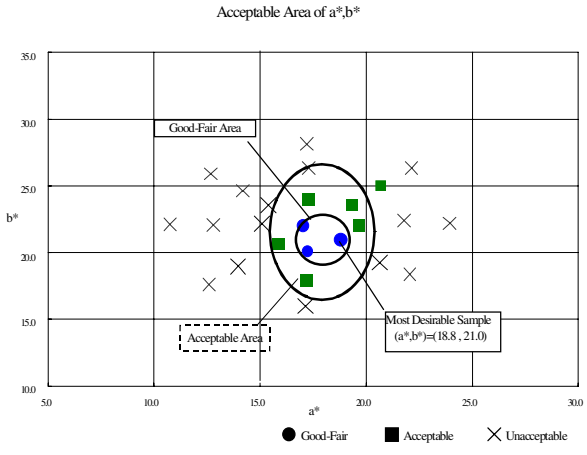


*Figure 5. The preferable skin tone represented in CIELAB diagram.*

 

## Discussions

**Standard Image**

In the present study, the standard image is established temporarily, supported by this psychophysical experiment and interviews of the observers. The requirements for standard image was considered and based on those considerations a standard image was designed. First, it is desirable to verify skin tone of the model. To achieve this we measure spectral reflectance of the model and compare it with those of the Standard Object Color Spectra Database for Color Reproduction Evaluation known as SOCS database.[10] The result is shown in Fig. 6. In Fig. 6, the measured data is compared with the average spectral reflectance of cheeks for Japanese females. It is found that the measured data is very close to the average, although a noticeable discrepancy is found in wavelength over 650nm.

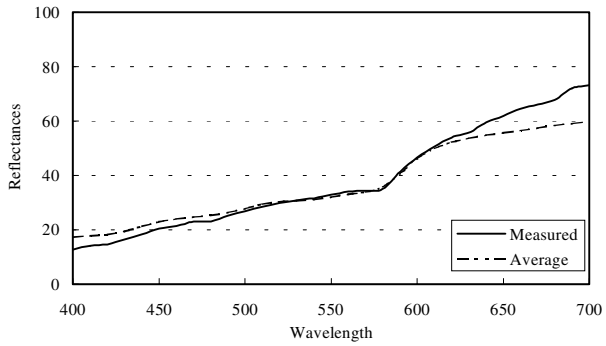


*Figure 6. The measured skin color compared with the average of cheeks for Japanese females.*

After the each session of the psychophysical experiments, we conducted interviews to each of observers to ask whether the image was appropriate for image quality assessment. The observers confirmed that the image was appropriate for the assessment in terms of skin tone, the face size and background and so on. This suggests that the standard image designed in the experiment seems to meet the requirements previously discussed successfully. From the interviews, many observers addressed an opinion that judgement would be more reliable if they are permitted to gaze the standard image for comparison.. Further investigation might be required between the standard image and psychophysical experiments.

We convince that the present standard image associated with a digital file will be extensively applicable to various experiments between cross-media under a variety of conditions. However, at the same time, it should be noted that the reliability of the standard image will be further examined through psychophysical experiments between cross-media under a variety of viewing conditions.

## Future Works

The following works will be required to establish the more reliable standard image and to provide recommendation for the psychophysical experimental method.

1. Improve visual assessment which is reliable and stable with minimum stress on observers by comparative study of various procedures.
2. Refine the standard image for visual assessment on the process of establishment of the standardization.
3. Examine the validity of the results from the viewpoint of statistical data analysis.
4. Propose the standard image and the standard psychophysical experimental method after the achievement of above works.

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