LOGO Blaž Baromić
30th September -2 th October 2009, Senj, Hrvatska

INFLUENCE OF AWB ON THE REPRODUCTION QUALITY AT DIFFERENT LIGHT SOURCES IN DIGITAL PHOTOGRAPHY

Mario Periša[1], Dean Valdec[1], Nikola Hrženjak[2]
[1] Polytechnic of Varaždin, Croatia
[2] Varaždinske vijesti d.d. , Croatia

Summary: *The light in a photographic process is of major importance for the overall quality of reproduced scene. In practice, a photograph is made in different lighting conditions and out of different light sources.*
Light sources emit the radiating energy of continuous spectrum which is being perceived to a human eye as white light. The emission of this radiation, its density, is defined as the temperature of the color of light.

This paper will demonstrate influence of different color temperature (light sources) on the quality of digital photography with automatic white balance (AWB) at constant remaining parameters.
Color gamut was defined by using colorimetric analysis of test chart photograph shooting in three different lighting conditions. On the basis of CIELAB value for three different conditions and standard value, color differences (ΔE) were calculated for primary (RGB) and secondary (CMY) colors additive synthesis.

Key words:
Digital photography
AWB Automatic white balance
Light sources
Color gamut

1. INTRODUCTION

In everyday photographic practice, especially photojournalism, due to varying field conditions, automatic white balance is being used.
White Balance is the ability of a camera to adjust the color balance of a picture to compensate for the ambient lighting. It adjusts the image settings for the type of light under which we are photographing. It can be automatic or manual. It is easy to see that fluorescent lights have a different color from incandescent lights. These are both different from the light that a photo flash gives off, and they are all different from the color of the light from the sun. This is often adjusted automatically in digital cameras, and it makes picture taking easy. If a camera possesses this function it is said to have "auto white balance."
Automatic White Balance is a system for automatically determining white balance. When color of the light changes, the human eye adapts so that a white object still looks white; this ability is called chromatic adaptation. On the other hand, devices such as digital still cameras see a white subject as white by first adjusting the balance to suit the color of the ambient light around the subject. This adjustment process is referred to as matching the white balance. The auto white balance (AWB) system did a perfectly good job in daylight but struggled under any form of artificial light, producing a strong color cast.

2. EXPERIMENTAL PART

2.1. Description of problem

When you are taking photos and the lighting conditions are perfect, then digital photography lighting is not a problem. Unfortunately, most of the time, the conditions are not ideal so photographers have to learn to use light to get desired results.
Different types of light have different “temperature”. Cooler temperatures come out looking blue, while warm temperatures appear yellow or red in your photo. The best color for a shot is a neutral temperature. All this means that white objects in the picture actually look white. If you can achieve a proper white balance, you will notice the coloring of your pictures comes out more like what it looked like to your eye when you snapped the shot.
Usually, the easiest way to adjust your white balance is to let the camera do it for you using the “auto white balance” feature. The problem with auto white balance is also the same as any other auto feature on your camera; the sensors just are not as good as your eyes. Start with the auto white balance on. If the white in the picture does not look white to you, then you can start adjusting.

2.2. Methodology

The experimental part is based on measurement evaluation by using standard color table IT8.7/1 for reflection materials. The define CIELAB value for standard color table was used as a reference data.

Figure 1: Standard color table IT8.7/1

Measurement evaluation is based on shooting the references color table in three different lighting conditions. The basic target was used constant exposition measured with camera photometer (TTL system). The time exposition was variable dependence of intensity and light source.
For shooting we used Canon 5D digital camera with Canon EF 135mm f/2 L USM. Constant settings were used all the time except exposition, including aperture f=1:5,6, ISO=100, metering mode was set to evaluative, and white balance to AWB (automatic white balance). Maximum exposition time difference was 1/3 of exposure. The photo is saved as jpeg under highest quality and sRGB color space.

The standard color table was placed on the back wall of Judge II-S stationery viewing booth. The Judge II-S gives you the ability to detect metamerism, or colors that match under one light but not under another, with the flexibility of five different light sources. Utilize either simulated daylight (D50),(D65),(D75) cool white fluorescent (CWF) at 4150K, incandescent (a typical light bulb) home lighting, custom fluorescent (TL84 or U30), or ultraviolet (UV).

Figure 2: Judge II-S stationery viewing booth

The photographs were being shot in the three defined light sources:

D65 (6500K) - A light bluish colored light source used in color matching applications of paints, plastics, textiles, raw inks, and other manufactured products. It is the only daylight source that was actually measured. The other daylight sources (D75 and D50) were mathematically derived from these measurements.

Cool White Fluorescent (CWF) - A wide band single phosphor fluorescent source commonly used in commercial lighting applications (typical store and office lighting). It is characterized by emitting high amounts of green energy, with a color temperature of approximately 4100K.

Illuminant A (2865K) is a common household light bulb that is yellowish red in color.

Shot photographs were uploaded to the Profile Maker program and created ICC profiles for each lighting conditions. All profiles were imported in ColorShop X program showing which profile had a bigger gamut represented in figure 3.

With Adobe Photoshop CS3 program CIELAB values for primary (RGB) and secondary (CMY) color additive synthesis were determined and compared to the standard value. On the basis of the measurements for three different conditions and standard value color differences (ΔE_{ab}) were calculated (Table 5).

3. RESULTS AND COMMENTS

The results of the colorimetric measurement at three different lighting conditions are presented in table 2 to 4. The values of the color sample measured on standard color table IT8.7/1 are presented in table 1.

Table 1. References data of standard color table IT8.7/1

Sample colour	References		
	L	a	b
white	90.14	1.21	-2.10
red	33.96	54.10	38.87
green	35.06	-50.57	30.12
blue	11.82	25.44	-52.45
cyan	37.85	-43.62	-33.87
magenta	43.2	64.08	-26.98
yellow	73.53	14.61	89.92

Table 2. Measurement results for the 7 sample of color at "A" light source

Sample colour	"A" light source		
	L	a	b
white	77.0	9.0	23.0
red	40.0	63.0	54.0
green	30.0	-39.0	34.0
blue	11.0	16.0	-28.0
cyan	44.0	-32.0	-20.0
magenta	44.0	66.0	19.0
yellow	71.0	25.0	81.0

Table 3. Measurement results for the 7 sample of color at "CWF" light source

Sample color	"CWF" light source		
	L	a	b
white	79.0	-1.0	0.0
red	29.0	43.0	37.0
green	32.0	-44.0	31.0
blue	17.0	31.0	-56.0
cyan	46.0	-13.0	-44.0
magenta	38.0	55.0	-35.0
yellow	72.0	2.0	80.0

Table 4. Measurement results for the 7 sample of color at "D65" light source

Sample color	"D65" light source		
	L	a	b
white	78.0	0.0	-1.0
red	31.0	51.0	42.0
green	31.0	-47.0	32.0
blue	18.0	26.0	-54.0
cyan	49.0	-26.0	-38.0
magenta	40.0	59.0	-28.0
yellow	67.0	15.0	76.0

It was necessary to explain that the color management system was not applied on the measured data at three different lighting conditions.

After the colorimetric values (CIELAB) were measured the colorimetric difference was calculated between the reference data and measured data at three different conditions.

The colorimetric difference (ΔE) was calculated on the basis of the following equation:

$$\Delta E_{ab} = (\Delta L + \Delta a + \Delta b)^{1/2} \quad (1)$$

Table 5. The colorimetric difference (ΔE_{ab}) between references data and measurement data at three different light conditions

Sample color	ΔE_{ab} (reference-measurement)		
	"A"	"CWF"	"D65"
white	29.4	11.5	12.2
red	18.5	12.3	5.3
green	13.2	7.3	5.7
blue	26.2	8.3	6.3
cyan	19.1	33.2	21.2
magenta	46.0	13.1	6.0
yellow	13.9	16.1	15.3

Table 5 shows that the greatest colorimetric difference is on the photograph shot at "A" light source. At other observed cases the difference is smaller especially at "D65" light source.

The colorimetric difference data was so huge because the color management system was not used. Exactly the real data without color management shows that the deviations at differences light sources for some color was too huge and unacceptable. These data can be useful to photographers for using AWB.

Just as we have expected, the smallest color divergence from the reference is with the light source "A" within the field of red and yellow because the spectral content of the light itself. This fact could be used while in the studio photographing the motifs that have the mentioned tones prevailing - the tones which give us the wider gamut during the reproduction.
At "CWF" and "D65" light sources the colorimetric difference is equal with most of the samples except for red and cyan.

The comparison of color reproduction at three different light conditional was represented by the top view of the gamut in xyY color space. The polygons are determined by the chromatic coordinates (x ,y) of the primary and secondary colors additive synthesis.

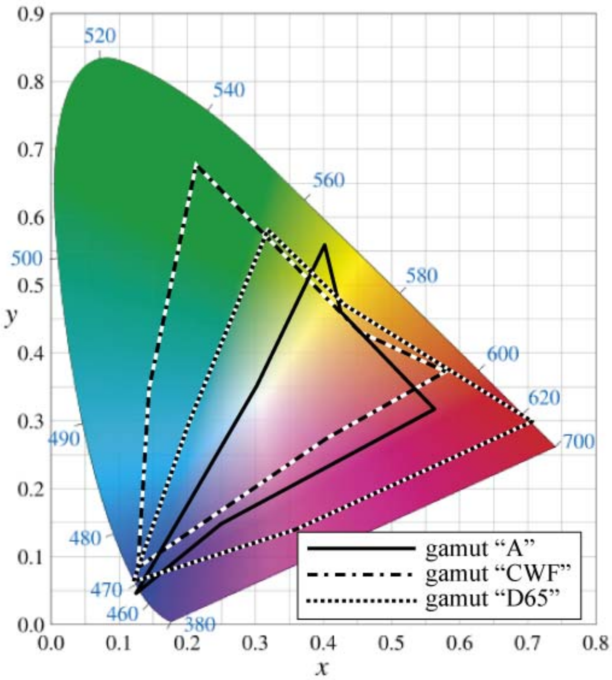

Figure 3: Gamut contours in CIE xyY color space for three different lighting conditions

4. CONCLUSION

The use of AWB is producing significant deviations for the different light sources. However, taking this into consideration, it is possible to expand the range of the color scale for the specific patterns which we shoot with the default light.

As we can see from CIE xyY chromaticity diagram shown, depending on the light source of the scene, we can achieve different color gamut. Under the A light source, we have a smaller gamut in comparison to the other two, and we will get worse results shooting under this light. On the other hand, under CWF light source, our complete gamut is moved to the green area of color diagram, which means that we can achieve much more green hues and less red ones. And as we could have expected, the best results we are getting if we shoot under D65 light source. Under it we get the largest gamut, and well balanced coverage of all visible colors.

No matter the type of the lighting, we can get a satisfying quality depending on the wanted areas of the color reproduction.

In this paper, certain theses that the profession meets in everyday practice, have been confirmed exactly. The recorded facts can direct us towards further research in this field of color reproduction.

5. REFERENCES

Freeman M. (2006), *The Complete Guide to Light & Lighting in Digital Photography,* U.S.A.

Huss D. (2005), *Digital Photography*, McGraw-Hill/Osborne, Emeryville, U.S.A.

Kipphan H. (2001), *Handbook of Print Media*, Springer-Verlag Berlin Heidelberg New York

White R. (2006), *How Digital Photography Works*, Que Publishing, Canada

http://www.photoxels.com/tutorial_white-balance.html Accessed: July 1, 2009

http://www.cambridgeincolour.com/tutorials/white-balance.htm Accessed: July 1, 2009

http://www.rondayphotography.com/Understanding%20the%20RAW%20File%20Format.htm Accessed: July 1, 2009