Assignment 1: white balance

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The problem

We are given a set of two pictures,

one taken while a single light source is in scene and the other in the same situation exactly (as well as the exposure, aperture, and white balance).

except that ,we get a photograph of a gray card took only with flash light source.

the problem we need to solve is to find a way to get a white balanced picture from the original-no flash picture.

For doing that we need first to find the original picture's light source, than fix it to be equalized.

This proccess as shown in the lectures can be done in several ways:

1. Applying the correction directly on the RGB channels.

2. Applying the correction on the XYZ representation of the image.

3. Applying the correction in LMS. For doing that we need to move from XYZ to LMS. And we saw several ways to do so.

Solving the problem

Extracting light source

Assuming a simple image formation model as in the ex description:

$$\bar{I} = \bar{R}\left(k_1\bar{L}_1 + k_2\bar{L}_2\right) \tag{1}$$

We have the image with the flash

with $k_1, \bar{L}_1$ of the original light source, and $k_2, \bar{L}_2$ of the flash

$$\bar{I}_1 \quad = \quad \bar{R}\left(k_1\bar{L}_1 + k_2\bar{L}_2\right) \tag{2}$$

We also got the original image to WB :

And in addition we got the $L_1$from the gray card picture

$$\bar{I}_2 = \bar{R}k_1\bar{L}_1 \tag{3}$$

So we can get:

$$(2) - (3) \quad \Rightarrow$$
$$\bar{I}_1 - \bar{I}_2 = \bar{R}\bar{L}_2 k_2 \tag{4}$$

$$\Rightarrow {}^{(2)}/_{\bar{R}\bar{L}_2 k_2} = \frac{\bar{I}_1}{\bar{I}_1 - \bar{I}_2} = 1 + \frac{\bar{L}_1 k_1}{\bar{L}_2 k_2}$$

$$\Rightarrow \quad \tfrac{\bar{I}_1 \bar{L}_2}{\bar{I}_1 - \bar{I}_2} \quad - \bar{L}_2 = \bar{L}_1 \cdot \frac{k_1}{k_2} \tag{5}$$

Now, since we care only about the proportions in L_1we can write:

$$\frac{\tfrac{I_1 L_2}{I_1 - I_2}_R - L_{2_R}}{\tfrac{I_1 L_2}{I_1 - I_2}_G - L_{2_G}} = \frac{L_{1R}}{L_{1G}}.$$

and the same for other channels. So by fixing certain channel to 1 we can get the L_1.(up to a constant)

Next, we should avrage this results on many pixels in the images and we should get quite accurate results.

In our solution, here we tried to take out the outliers as the flash shadows and the burned places.

Using the light source in order to get white balance

RGB correction:

simply multiply the channels in ${}^{1}/_{L_{1RGB}}$

XYZ correction:

we first need to move both the picture and the $\bar{L}_1$ to XYZ , make the correction , and back to RGB.

LMS correction

using the equation from class, we need to move to XYZ. Then, to LMS ,using one of the methods, apply the correction, and back.

Important remark:

For RGB to XYZ convertion we used a matrix we found in the Internet, and asked the 'dcraw' output to be in the RGB working space that's agrees with it. (namely, using -o 1 option)

Expectations and Limitations

General Limitations:

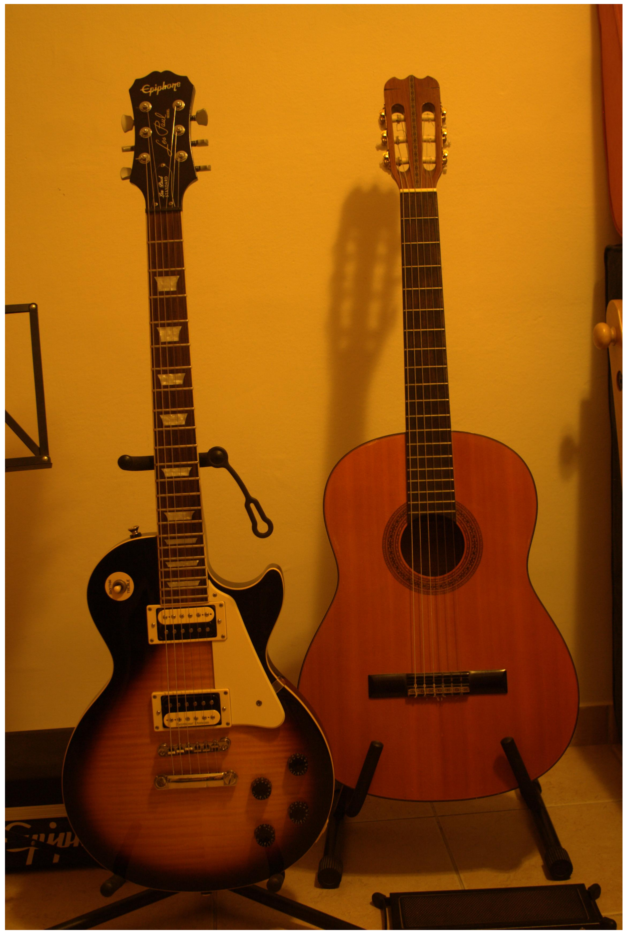
We expect all this approach of white balancing to fail in cases with especially low/ high illumination, since in those situations we can get much noise/ to many burnt places, in the input pictures, so the L_1 extraction will generate bad results. For that reason we think that outdoor samples for example (taken at day and night) will not do very well, since the sky at day time produces light, so the sun is not exactly a single light source, as well as the narrow and short range of the flash at night time. (We never actually tried anything but the given samples due to time limitations...)

In addition, in scens with a very few dominant colors, there is more ambiguity about the L_1 source since the color could be interpreted as the light source colors or the photographed subject colors. So in these cases too we expect poor results.

method based expectations:

We expected the RGB balance to work pretty well in general cases (in the frame of the limitations above), because it gives a shift to the light source in the natural representation. so not much could go wrong. On the other hand no special boosts is added in this way.

Figure 1: Original image



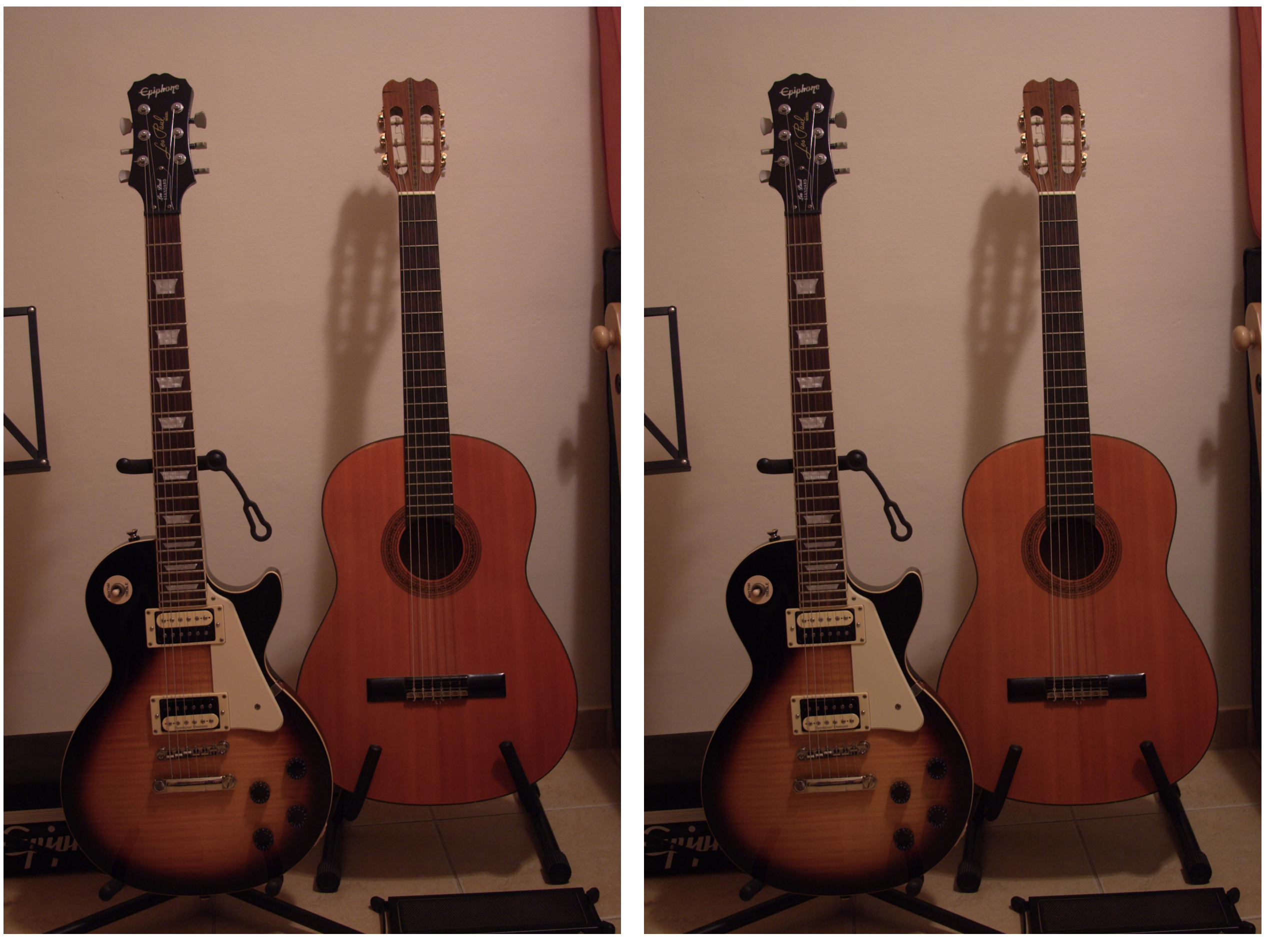
Next, we expected the XYZ to give the poorest results since it corrects the picture in unnatural environment on the one hand, but still dosn't get any thoughtful enhancements. In addition, it involves the transformations, which we are not sure are accurate.

The LMS white balance was our biggest hope, since it suppose to use an even more natural environment at least for the brain. And in theory, this method should give the best results, in hope that the transformations expected inaccuracy wont hurt too much, and that we could find the optimal transformation (e.g Von-Kries, Bradford, etc.).

results

CIECAM02 is allmost simmilar to Bradford, and it seems to me that Von Kries has a bit better results of the two.

Figure 2



(a) LMS White balance using Bradford

(b) LMS White balance using Von Kries

Figure 3

(a) LMS White balance using CIECAM02

(b) LMS using Von Kries with D65 normalization

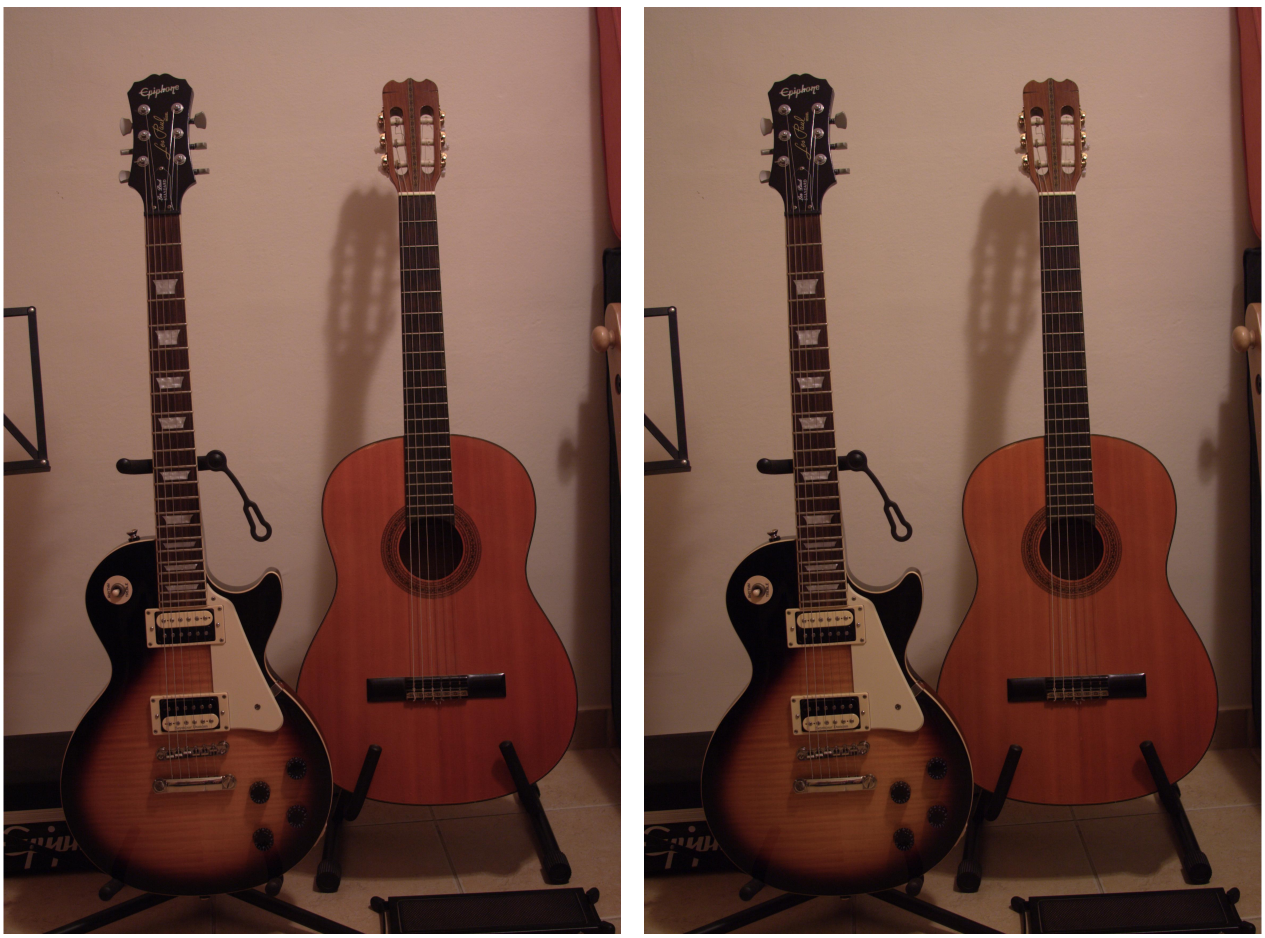
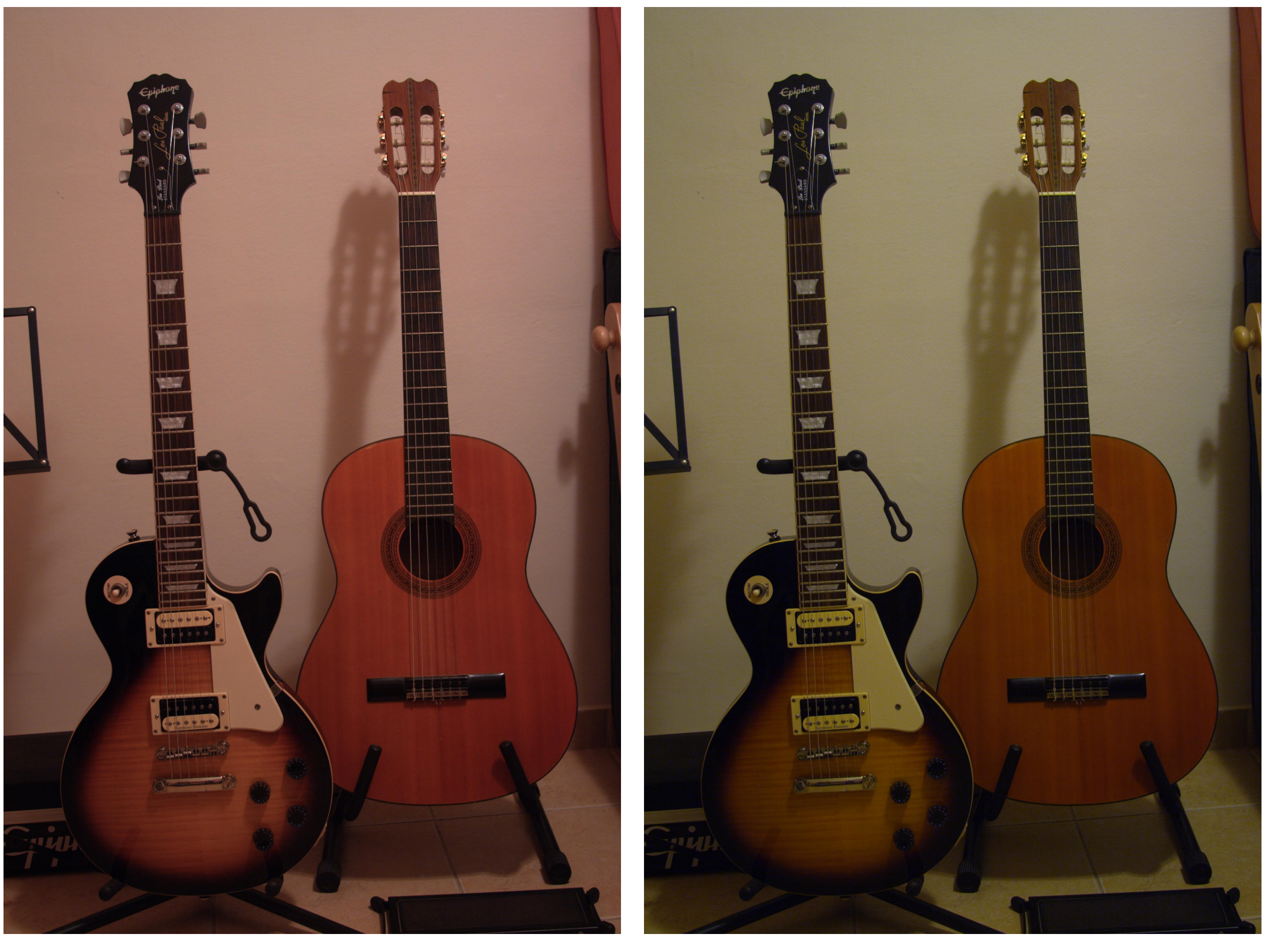


Figure 4

(a) XYZ White Balance

(b) RGB White Balance



indeed, the XYZ seems to output the worst results, and at least for my opinion the RGB results are not bad.

conclusion

it seems that all of the methods gave a range of reasonable results. Some are more agreeable to be worst, but for some, it is might be a matter of taste, and perhaps different interpretation of the colors in one's brain. and still, it would be reasonable assumption to make, that on some scenes more people will agree on one method over the other, but in another scenes it might be other method to be the best.