Homework
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Homework Exercise 2.5.1

In this assignment we will try different white balance algoeithms. A white balance model consists of implementing a chromatic adaptation model. It is applied to compute the corresponding image taken under any light source to the image under a defined illuminant, usually D65. Therefore, we need the XYZ values of each pixel in the original image, and the XYZ values of the original light source, or XYZ of perfect white under it.

Estimating the reference light source

1. Method 1

We assume the brightest object/pixel in the image is white, and the XYZ of that object is considered as the original illuminant in the chromatic adaptation. It is recommended that we choose the brightest pixel as the pixel with highest achromatic channel computed from:

$A = 2L + M + 1/20*S$

To implement this, I made a function named "methodone.m" in which the input is the RGB image. This function takes the image, goes from sRGB to XYZ, and from XYZ to cone space using the Hunt-Pointer-Stevez matrix. Then, using the mentioned formula, we go from cone space to achromatic channel, and finding the pixel with maximum A, the function returns the RGB value of that pixel from the original image.

2. Method 2

Manually select a white object and use its XYZ values for the transformation.

To implement this, I made the function "methodtwo.m", which opens the image and asks the user to select a pixel from the image that is white. Then, the function returns the RGB values of that pixel.

3. Method 3

In this method we assume that the average color from the image is medium grey. We obtain the average of RGB channels of all the pixels in the image, and we use that average chromaticity along with the luminance of a perfect white for the transformation:

$$x_{av}, y_{av}, Y=100$$

To implement this, I made the function "methodthree.m", which takes the image, compute the average R,G, and B; calculates the avergae chromaicity, and returns the XYZ from the bellow formula:

$$X = x_{av}/ y_{av}*Y$$
$$Z = ((1-x_{av}-y_{av})/y_{av})*Y$$
$$\text{With } Y=100$$

The output of each one of the methods, will later be used as the color data of the source light source in the chromatic adaptation models.

Chromatic adaptation models

1. von Kries

Once we have the source light source (from either mentioned methods) and the destination light source (here D65), we will apply the adaptation method on the image.
In the MATLAB script for the von Kries methos (“ArfaieOghani_HW_2_5_1_VonKries”), you can see that from the XYZ of the source and destination light source, their corresponsing LMS is calculated (the Hunt-Pointer-Stevez matrix) which will be needed later. Then creating the conversion matrix (M_conversion) that goes from XYZ of the source image to XYZ of the destination image, we complete the adaptation. The conversion matrix is created as follows using the Hunt-Pointer-Stevez matrix and LMS of source and destination lights:

$$\text{M\_conversion} = [M_{HPS}]^{-1} * \begin{matrix} \frac{L_{Destination}}{L_{Source}} & 0 & 0 \\ 0 & \frac{M_{Destination}}{M_{Source}} & 0 \\ 0 & 0 & \frac{S_{Destination}}{S_{Source}} \end{matrix} * [M_{HPS}]$$

Which

$$\begin{matrix} X_{Destination} \\ Y_{Destination} \\ Z_{Destination} \end{matrix} = [M_{conversion}] * \begin{matrix} X_{Source} \\ Y_{Source} \\ Z_{Source} \end{matrix}$$

In the end, we go from XYZ to sRGB and visualize the image.

2. CAT02

For this adaptation, we have another MATLAB script “ArfaieOghani_HW_2_5_1_CAT02”. Again we have the XYZ and LMS of the source light souce and destinatition light source. The following conversion is taked place in order to do the CAT02 adaptation:

$$\text{M\_cat02} = \begin{matrix} 0.7328 & 0.4296 & -0.1624 \\ -0.7036 & 1.6975 & 0.0061 \\ 0.0030 & 0.0136 & 0.9834 \end{matrix}$$

$$\begin{matrix} X_{Destination} \\ Y_{Destination} \\ Z_{Destination} \end{matrix} = [M_{cat02}^{-1}] * \begin{matrix} \frac{R_{Destination}}{R_{Source}} & 0 & 0 \\ 0 & \frac{G_{Destination}}{G_{Source}} & 0 \\ 0 & 0 & \frac{B_{Destination}}{B_{Source}} \end{matrix} * [M_{cat02}] * \begin{matrix} X_{Source} \\ Y_{Source} \\ Z_{Source} \end{matrix}$$

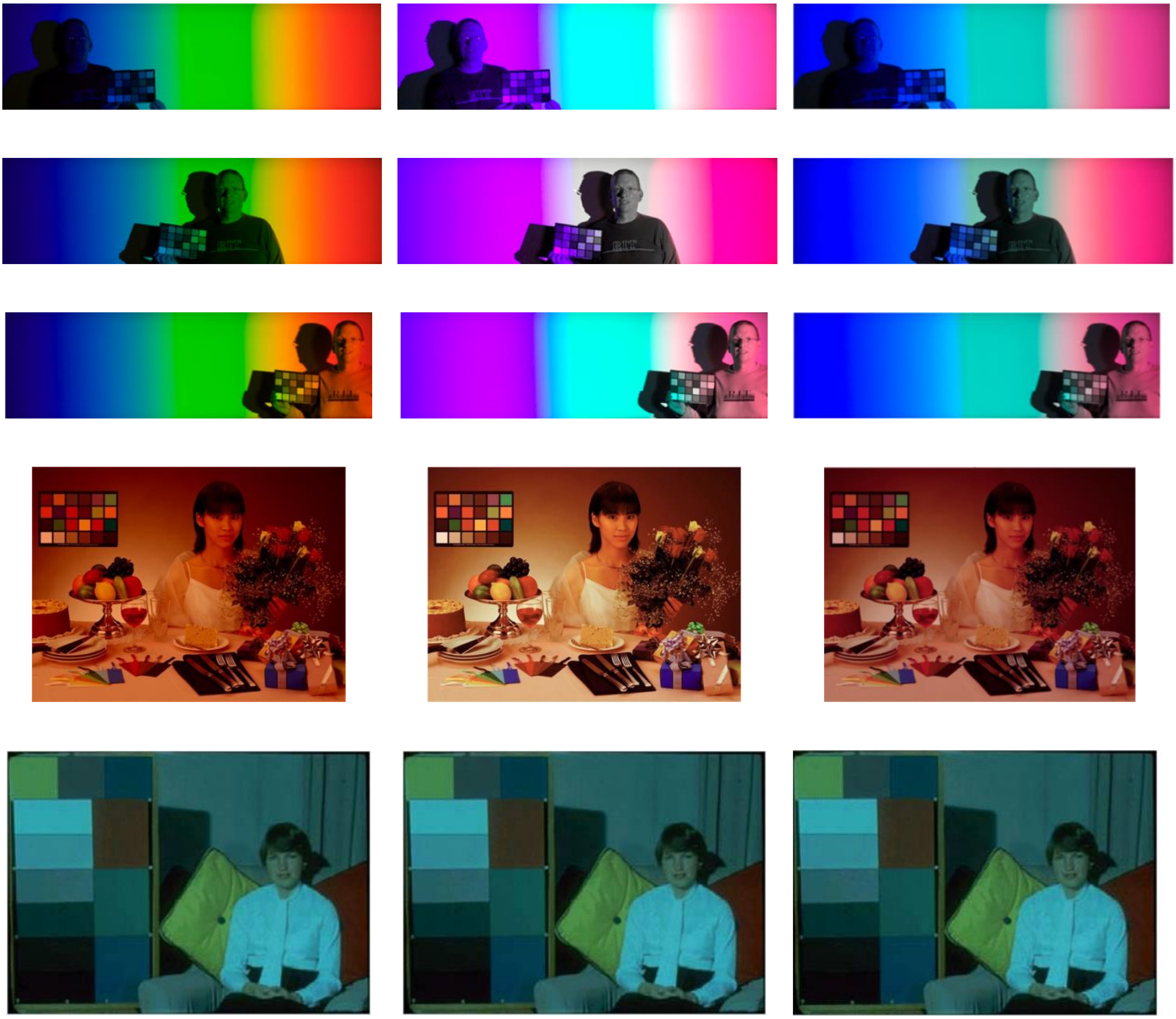
In the end, we go from XYZ to sRGB and visualize the image.

Results

Method 1, von Kries vs CAT02

The Follwing results, are for the method 1 of selectig the white point of the image. We see that this method has performed moderately for some images such as images of “Lab2_5-1_2”, “Lab2_5-1_4” and “Lab2_5-1_5”. However, we can also see that there is no adaptation happening in other images, indicating that method one is not suitable. We can’t say much about von Kries vs CAT02 as they are performing quite similar.

Original	**Von Kries**	**CAT02**



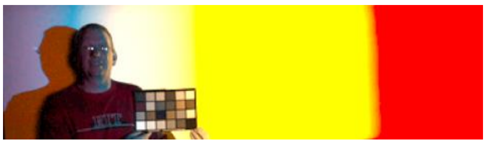




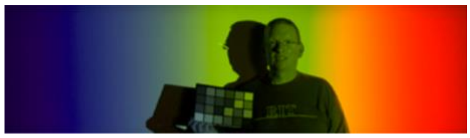
Method 2, von Kries vs CAT02

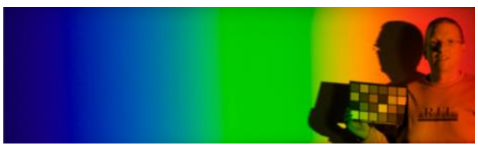
The Follwing results, are for the method 2 of selectig the white point of the image. We see that we have clear improvement from the method 1. First, we have to mention the first three images; the white patch from the color checker in all the three were chosen as the white pixel, with the previous knowledge of that patch being the “white”. It’s important to say that this method is very objective and by changing the white pixel by the user, the adaptation changes. However, we can see that in this method von Kries is achieving better results in most of the cases.

Original	**Von Kries**	**CAT02**





Method 3, von Kries vs CAT02

The Follwing results, are for the method 3 of selectig the white point of the image. We see that we have clear improvement on both of the adaptation techniques. We can see that in this method von Kries is achieving better results again. For the first three images we are still struggling to achieve a good adaptation. Here in method 3, no adaptation is happening for the three first images. We can

see that due to the complex nature of the image, having colored lights also shining on the color checker, makes it hard for each one of the methods to find a suitable white point representing the illuminant in the image. We are mostly assuming a global light source that shines on the whole scene; however in these images, we have multiple light sources.
Comparing method 2 and method 3, we can say that method 2 creates images with higher contrast, while method 3 creates more dim images which we can see that are more natural. Therefore, we can say that von Kries performs overally better combined with method 2.

Original	**Von Kries**	**CAT02**

Reference

The functions that were used in this assignment, srgb2xyz.m, and xyz2srgb.m are a part of the ColorEngineeringToolbox written by Phil Green.