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Homework 3

Ex 2.9: White point balancing—tricky

A common (in-camera or post-processing) technique for performing white point adjustment is to take a picture of a white piece of paper and to adjust the RGB values of an image to make this a neutral color.

1. **Describe how you would adjust the RGB values in an image given a sample "white color" of (Rw , Gw , Bw) to make this color neutral (without changing the exposure too much).**

This problem appears when we take a picture and the ambient light can have a color 'cast' that is captured by cameras, whereas the human eye adapts automatically to it. For example, if we take a picture of a white paper, we should be getting equal values, but because of this problem we get something like: Rw = 230, Gw = 240, Bw = 245. To adjust the rgb values to make the color neutral, we perform per-channel scaling. This involves computing scaling factors for each rgb channel based on the sampled white color and applying them to the entire image.

The first step is to calculate the scaling factors:

$$S_r = \frac{1}{R_w}, S_g = \frac{1}{G_w}, S_b = \frac{1}{B_w}$$

The second step is to apply them for each pixel (R, G, B) of the image:

$$R' = R \times S_r = \frac{R}{R_w}, G' = G \times S_g = \frac{G}{G_w}, B' = B \times S_b = \frac{B}{B_w}$$

This process achieves white balance by transforming the white reference point to (1,1,1), which proportionally adjusts all other colors in the image, removing any color cast without significantly altering the overall exposure.

2. Does your transformation involve a simple (per-channel) scaling of the RGB values or do you need a full 3 × 3 color twist matrix (or something else)?

Per-channel scaling doesn't require a full 3x3 color twist matrix. It adjusts each color channel independently based on the sampled white point, effectively neutralizing the color cast without altering the image's exposure or other color relations. However, per-channel scaling is a diagonal transformation and assumes that the primary color imbalance lies solely along each rgb axis independently.

3. Convert your RGB values to XYZ. Does the appropriate correction now only depend on the XY (or xy) values? If so, when you convert back to RGB space, do you need a full 3 × 3 color twist matrix to achieve the same effect?

X and Y represent chromaticity coordinates that contain the color's hue and saturation, and Z complements them to complete the color representation, such that adjusting X and Y also affects Z, to maintain the color consistency. The conversion should be done using a full 3x3 color twist matrix, because of the interrelations between all 3 channels, which cannot be addressed by per-channel adjustments alone.

4. If you used pure diagonal scaling in the direct RGB mode but end up with a twist if you work in XYZ space, how do you explain this apparent dichotomy? Which approach is correct? (Or is it possible that neither approach is actually correct?)

The dichotomy between pure diagonal scaling in the direct rgb mode and a twist in the XYZ space arises from the fact that these 2 methods treat the color information differently. Per-channel scaling assumes that each color channel can be manipulated independently without affecting others, due to the fact that the rgb space is non-linear, while in the XYZ space, correction involves all three channels due to their collective role in representing color. This leads to a difference of approach between these 2, such that the per-channel scaling in rgb is equivalent to applying a diagonal matrix, while for the other one requires a 3x3 matrix.

Both approaches are correct depending on the situation, per-channel scaling in rgb is the faster alternative, being straightforward and used for when the color cast is distributed evenly across each channel. For the XYZ space, the full 3x3 matrix transformation provides a more accurate representation of color adaptation, as it considers the interdependencies

between channels, making it more suitable for tasks that require a more precise color accuracy or when the color cast affects channels unequally.