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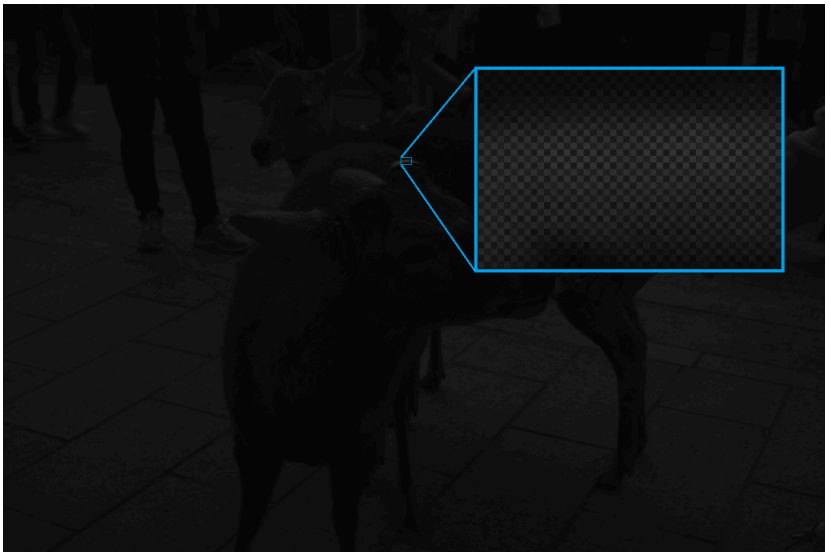
Assignment 1: Camera Pipeline

Importing your image

Reading the image into Matlab

The selected image has a resolution of **6024 x 4022** pixels and a bit depth of **16**, which determines the range of intensity values available for each channel.



Linearization

To linearize the raw image data, we applied a linear transformation based on the black and saturation levels:

$$L = \frac{I - I\,black}{I\,saturation - I\,black}$$

where:

- I is the original pixel intensity.
- I_{black} is the black level, set to 1023.
- $I_{saturation}$ is the saturation level, set to 15600.

After applying the transformation, pixel values were clipped to the range [0,1] to ensure valid intensity levels.

Effect of Parameters:

- Adjusting I_{black} affects the removal of noise in darker regions.
- Modifying $I_{saturation}$ influences the contrast and prevents saturation artifacts.

Demosaicing

Through analysis of the raw image data, we identified the Bayer pattern as **RGGB**. This pattern was used as a reference for demosaicing, ensuring an accurate reconstruction of the color image.

Bayer pattern: ‘rggb’

As observed, the coat of the person in the background appears red, accurately reflecting its original color in the raw image:

White balancing

These are the results using the different white balancing methods:

Gray World

Manual White Balancing

White World

In this case, we found that manual white balancing produced the best results. The White World method resulted in a noticeable violet tint, while the Gray World method introduced a strong blue cast. In contrast, the manually adjusted white balance provided a more natural and well-balanced color distribution.

Color balance

Before color balance

After color balance

Tone reproduction

In this step we first adjust the exposure of the image with the following equation, where the exposure ∝ is set to 1.4:

$$C_{adjusted} = C_{linear} * 2^{\alpha}$$

Then the gamma correction is applied with the following equation with gamma being 1.1:

$$C_{non-linear} = \begin{cases} 12.92\ C_{linear}, & C_{linear} \leq 0.0031308 \\ (1+0.055)\ C_{linear}^{1/\gamma} - 0.055, & C_{linear} > 0.0031308 \end{cases}$$

Compression

Here, you can see the contrast between the raw reference image and the result produced by our camera pipeline:

Original

Our Image

Full pipeline with a different image

In this case, we selected the Mecha image and used the `dcraw` executable to convert the provided raw image into a TIFF format. We then processed this image through the full camera pipeline. During this process, we identified that the image utilizes a different Bayer pattern (GBRG).

Bayer pattern: ‘gbrg’

We then compare the results obtained from the full pipeline using the provided TIFF image with those derived from the DCRAW-converted TIFF image:

Using the TIFF image

Using the RAW image