ISP Assignment Deliverable Report

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COMP 590

Repository: https://github.com/Alexandria-Anderson/ISPAssignment3

1.1 Basic Image Processing Pipeline

RAW image conversion using dcraw:

Black: 0

White: 16383

Red Multiplier: 1.628906

Green Multiplier: 1.0

Blue Multiplier: 1.386719

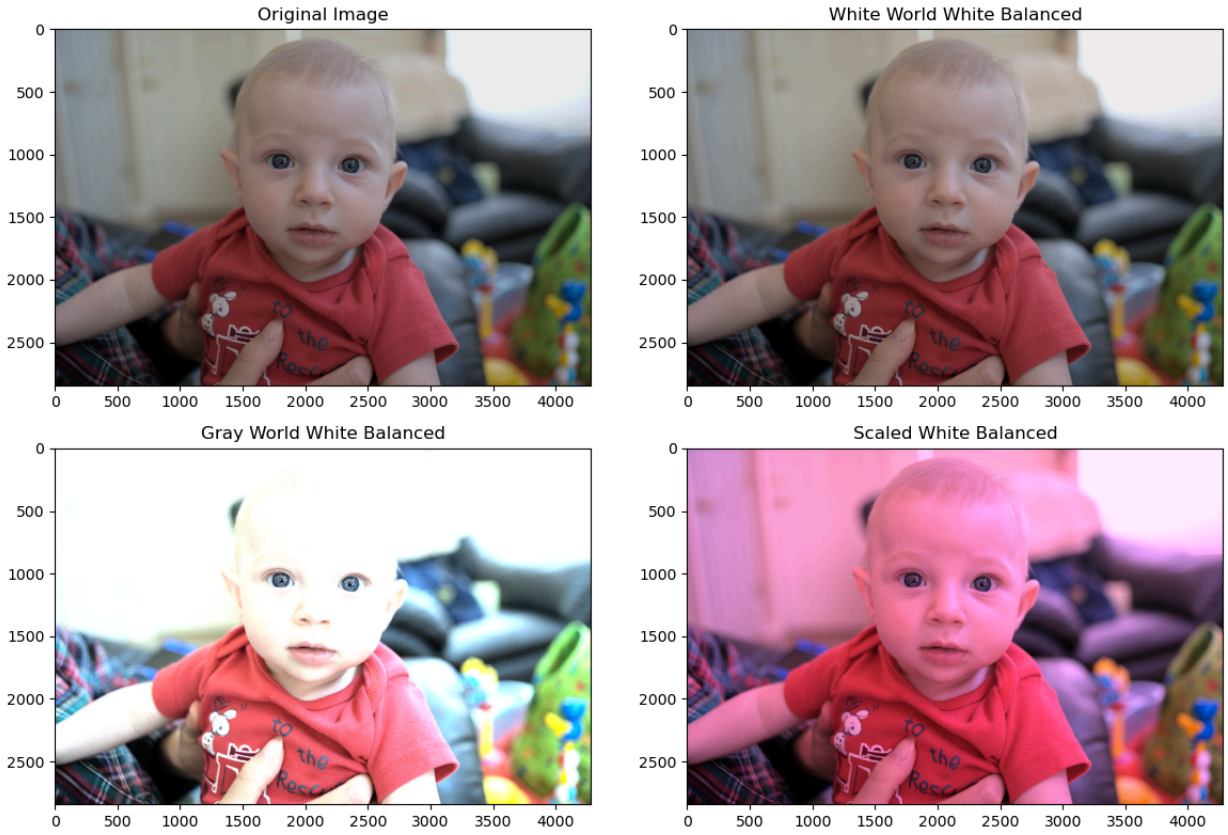
Python initials:

16 bits per pixel

Width: 4284 px

Height: 2844 px

Bayer Pattern: To identify the Bayer Pattern, we employed several different strategies. Initially, we wrote a script “1.1_BayerPattern” which sought to convert the image to a grayscale image initially, and using the RGB channels, identify which pattern the pixels correlated with the most. We cross-validated this with the Rawpy library, which resulted in the identification of the Bayer Pattern of this image as RGGB.



White Balancing: Above is the outputted images after the 3 balancing algorithms. Of the three, the white world balancing algorithm appeared the most effective at producing a more refined image.

Demosaicing and Color Correction

The demosaicing process was performed using the built-in interp2d function. Its implementation can be found in the demosaicing.py file. Color correction was performed using a combination of the PIL and os Python libraries.

Compression

When performing compression the main difference between the two resulting images is the resolution. The resulting baby.PNG has a noticeably higher quality than the JPEG.

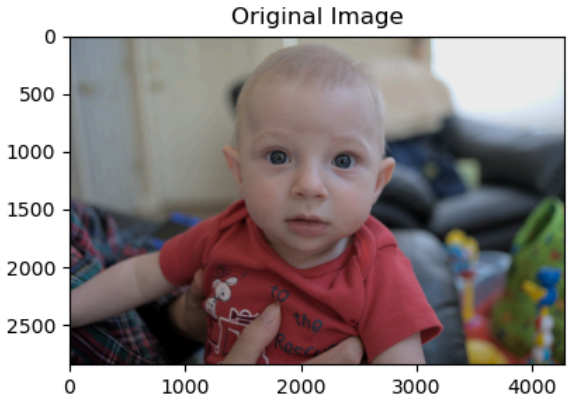
Compression ratio JPEG : PNG = 1 : 5.5

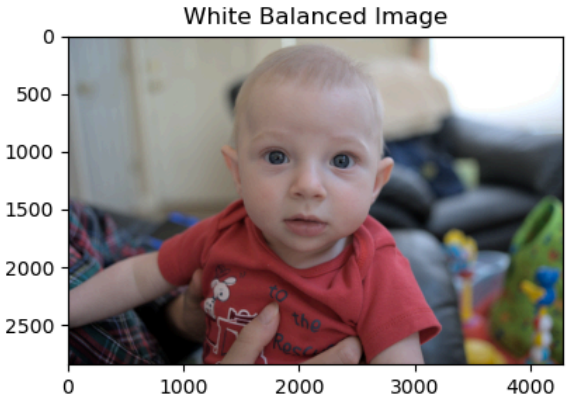
Note: We were unable to determine the lowest setting for which the jpeg is indistinguishable from the original. I encountered an error in the colorcorrection.py file when trying to compress

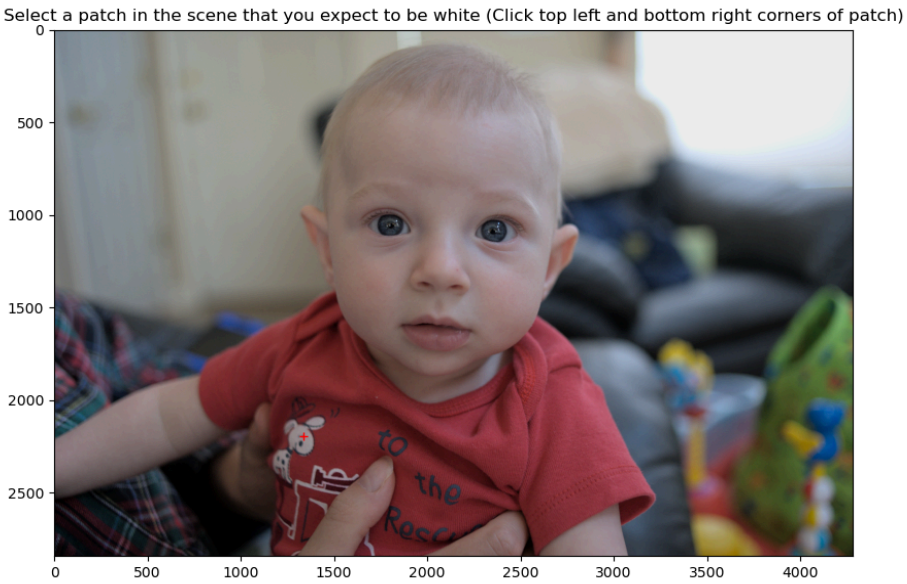
the images - the large file caused the code to run for 5 min + until I manually stopped it, making the comparison impossible.

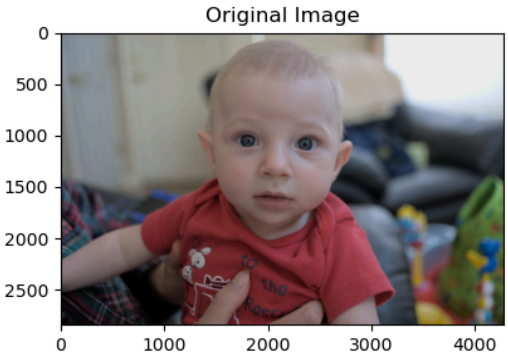
1.2 Manual White Balancing

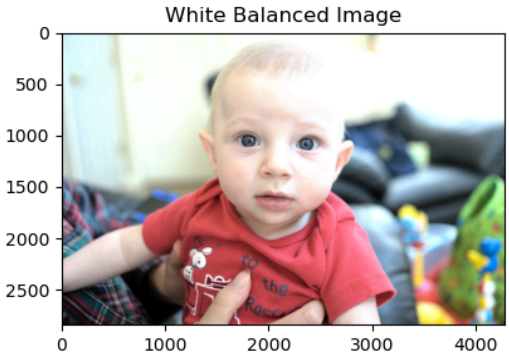
A separate script was written (1.2_ManualWhiteBalancing) that performs the patch-based white balancing of the image, and as you can see below when a patch of pure white is selected (top right corner of the original image), it seems to yield better results at white balancing than when a separate patch that also appears white is selected (white dog on the shirt). By ensuring that the brightest pixel in the image is white, and the other color channels are scaled accordingly, the white balancing algorithm yields a better result.


Original Image
0
500
1000
1500
2000
2500
0
1000
2000
3000
4000


White Balanced Image
0
500
1000
1500
2000
2500
0
1000
2000
3000
4000


Select a patch in the scene that you expect to be white (Click top left and bottom right corners of patch)
0
500
1000
1500
2000
2500
0
500
1000
1500
2000
2500
3000
3500
4000


Original Image
0
500
1000
1500
2000
2500
0
1000
2000
3000
4000


White Balanced Image
0
500
1000
1500
2000
2500
0
1000
2000
3000
4000

1.3 dcraw experimentation

Dcraw offers automatic demosaicing and linearization, so no flags are needed to specify these. To white balance an image, use the flag -w followed by the desired values - the image below uses 1.2, 1.0, 1.5. Brightness can be altered with the -b flag, gamma with the -g flag, and color space with -o. The image below uses a brightness of 1000, a gamma of 5.7, and the sRGB color space.

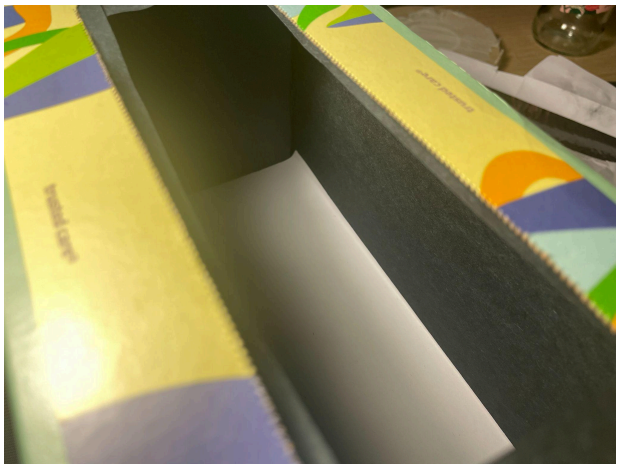
Image made with dcraw

Derived image

baby.jpeg

The JPEG image developed by the Nikon camera appears to have the most balanced rendering. It appears slightly lighter than the dcraw image and sharper than the ISP derived image.

2.1 Pinhole Camera



I made this Camera Obscura with a napkin case. The case is about 30cm in length, 15cm in width and 15cm in height. The focal length is the height which is 150mm. I covered one side of the case with white paper and all other sides with black paper. Screen size is 300mm x 150mm = 45000mm^2. FovX = 2*arctan(300/(2*150)) = 1.570, FovY = 2*arctan(150/(2*150)) = 0.927.

2.2 Use the pinhole camera

Scene 1

0.1mm pinhole, ISO 3200, shutter speed 30"

1mm pinhole, ISO 3200, shutter speed 10"

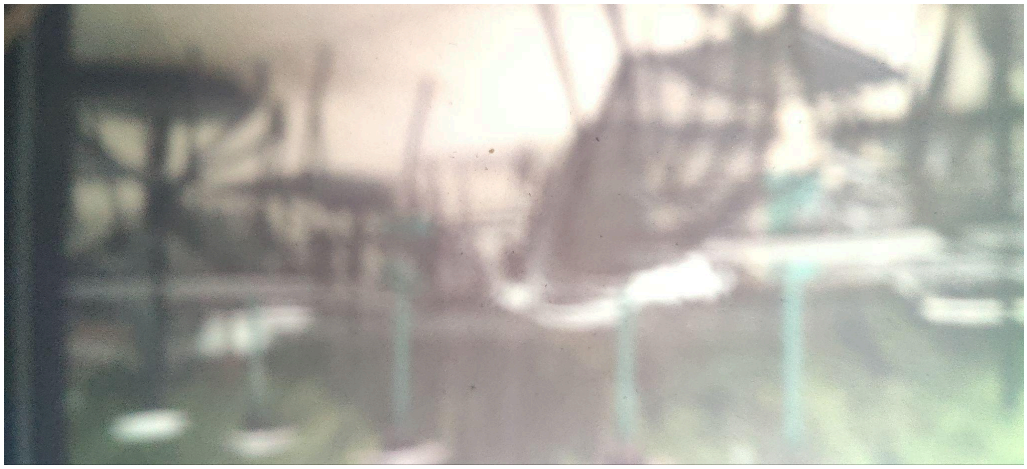
5mm pinhole, ISO 3200, shutter speed 4"

Scene 2

0.1mm pinhole, ISO 3200, shutter speed 30"

1mm pinhole, ISO 3200, shutter speed 10"

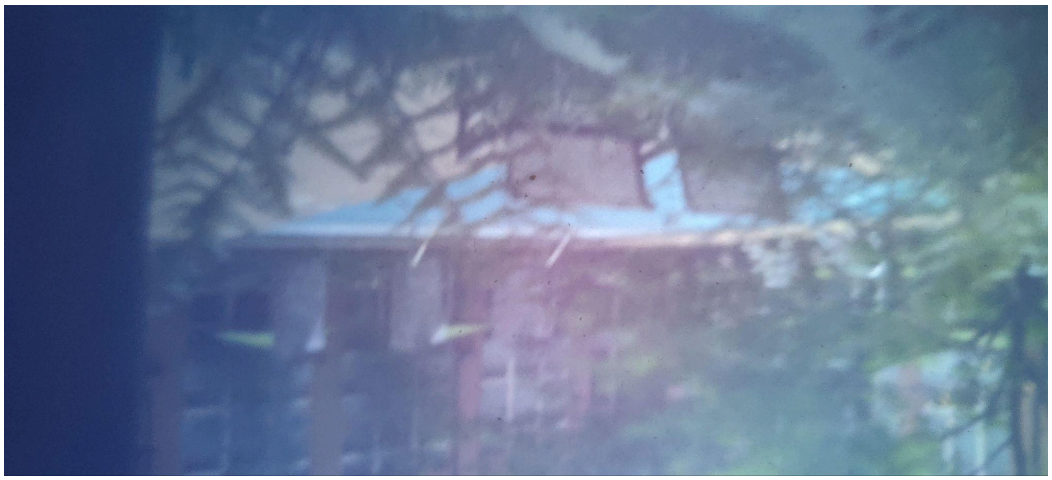
5mm pinhole, ISO 3200, shutter speed 2"



Scene 3

0.1mm pinhole, ISO 3200, shutter speed 30"

1mm pinhole, ISO 3200, shutter speed 10"



5mm pinhole, ISO 3200, shutter speed 2"

Discussion: All the pictures are upside down, consistent with the pinhole camera model. With the same ISO, the camera with smaller pinhole requires longer exposure. Notice there are significant reddish glows in the photos captured with 0.1mm pinhole. When light bends (diffracts) significantly, as it would with a very small pinhole, it can cause chromatic effects where different wavelengths of light (colors) bend at slightly different angles. Red light has a longer wavelength than other visible lights, so it diffracts more. This can result in a reddish glow or halo in the center of the image. Another potential reason could be light leaks. Since the exposure is very long, even a tiny light leak gets amplified. On the contrary, the photos captured by the 5mm pinhole have no reddish artifact but are blurry. As more light rays from each point of the scene can enter through the hole, it results in overlapping and less distinct focus points, which blurs the image. 1mm pinhole is in between -- the reddish artifact is not as significant and the image is relatively sharp. This is the best pinhole diameter for this camera.