Assignment 1

COL-783

January 2022

This goal of this assignment is to get started with image processing in python. You will demosaic an image and play around with different types of image transformation and enhancement techniques.

A. Demosaiking

In the first part, you will implement a demosaiking algorithm to convert a Bayer pixel pattern into an RGB image. In the raw image acquired by a camera, only one of the R,G,B color values is measured at any given pixel location. For this assignment, we represent the raw mosaic image as a gray-scale image with red, blue and green pixel values interleaved according to the pattern RGGB as shown below. Your task is to implement the interpolation technique presented by [1] and use it to demosaic the images in fig. 2. The corresponding original RGB images are also provided for reference. In order to compute the similarity between the original and demosaiced images, we will use the Peak Signal-to-Noise Ratio (PSNR), computed separately for each channel. For the red plane, for instance, the PSNR is computed as follows:

$$MSE^R = \frac{1}{XY} \sum_{x=0}^{X-1} \sum_{y=0}^{Y-1} (I^R_{x,y} - \hat{I}^R_{x,y}) \tag{1}$$

$$PSNR^R = 10 \log_{10} \left(\frac{255^2}{MSE^R} \right) \tag{2}$$

where I is the intensity of the original RGB image, $\hat{I}$ is the intensity of the demosaiced image estimated by you. X and Y are respectively the width and height of the image. You should perform demosaicing for all the three images in fig. 2 and for each image, compute the PSNR on each channel (R, G and B) by comparing with the original RGB images provided.

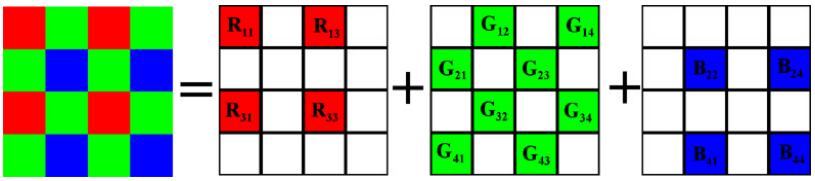


Figure 1: Demosaiking

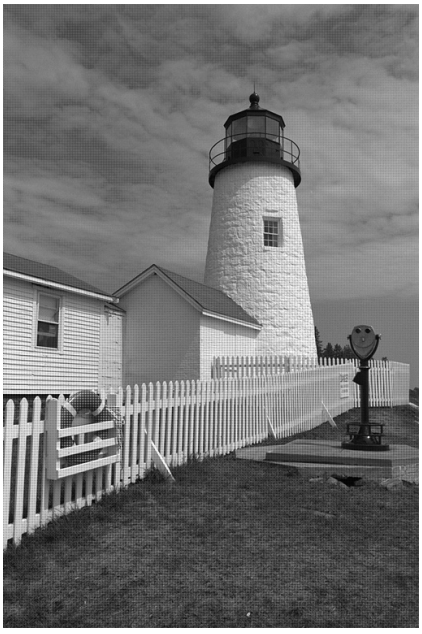
(a) RGB image

(b) Bayer image

(c) RGB image

(d) Bayer image

(e) RGB image



(f) Bayer image

Figure 2: Original RGB images and their corresponding Bayer sampled images

B. Image enhancement

In the second part of this assignment, you will use image processing techniques to visually enhance the quality of images captured under sub-optimal lighting or weather conditions. In particular, you will work with the following two types of images:

1. **Night-time images:** Images captured during night time often suffer from low brightness and contrast. To combat this, many smartphone cameras come equipped with *Night Mode*, which allows one to capture great shots, even in low illumination. Unfortunately, for this assignment, assume that you don't have access to a smartphone with Night Mode. Your task is to mimic

Night Mode by applying image enhancement techniques to regular night-time images. You are provided with three night-time images as shown in fig. 3. For reference, images of the same scenes captured using Night Mode are also provided. Additionally, capture one night-time image from your own smartphone (without night-mode) and try to enhance it. Include the results in your report.

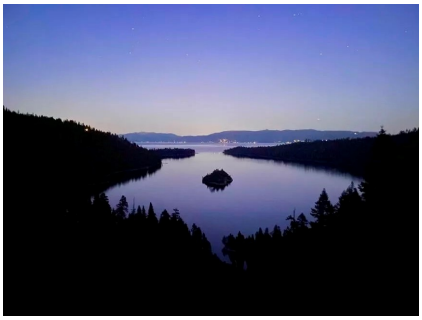
(a) Regular night-time image

(b) Image captured in Night Mode

(c) Regular night-time image

(d) Image captured in Night Mode

(e) Regular night-time image



(f) Image captured in Night Mode

Figure 3: Night-time images of three scenes captured without and with Night Mode

Hint: You may try gamma correction, histogram equalization and computational color constancy like retinex.

2. **Foggy images:** Images captured in bad weather conditions like fog and haze suffer from poor visibility, contrast and distorted color. Your task is to use image processing algorithms to improve the visual quality of the image by removing the fog. You are provided with three

foggy images as shown in fig. 4. For reference, images of the same scenes captured on a clear day are also provided.

Hint: Adaptive histogram equalization might help here.

(a) Foggy image (b) Clear image

(c) Foggy image (d) Clear image

(e) Foggy image (f) Clear image

Figure 4: Foggy and clear images of three different scenes. Your task is to defog the foggy images to try to get closer to the clear images.

Color spaces: While implementing the above image enhancements, you are encouraged to try out different color spaces like HSV, YUV, etc. For example, if performing histogram equalization, in addition to performing equlization in all the three channels of an RGB image, you can convert the image to HSV color space and perform equalization on the V channel only. Observe the effects of using different color spaces for different image processing techniques.

C. Video enhancement

Once you have familiarized yourself with image enhancement of night-time and foggy images, go a step ahead and do the same for a video sequence.

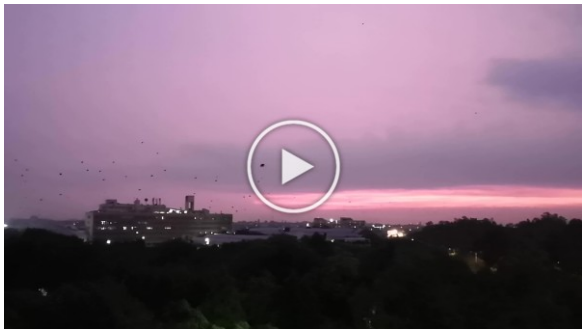


Figure 5: Video of a scene requiring enhancement

Rules

1. Write your own code for the demosaiking part. You are not allowed to use any in-built demosaicing functions.
2. For the image enhancement part, you are allowed to use pre-built library functions from OpenCV and scikit-image. If you use any other open-source code available on the internet, **do not forget to cite the source** in your report as well as code. If you fail to cite the source and your code happens to be similar to any of your classmate's, that will be considered as a case of plagiarism.
3. You can do the assignment in groups of two, or individually.
4. You are not allowed to discuss or borrow code from other groups.

Submission Instructions

1. Submit your source code, along with a readme.
2. Submit output files for all input images provided. The output file for a given image should be stored in the same directory as the input image.
3. Submit a detailed report mentioning the methodology, design choices, results and analysis. Outputs (along with corresponding input images) should also be clearly shown in your report.
4. Zip the code and report in a single file, rename the zip as <Member1-entry-number> _ <Member2-entry-number>.zip and submit on moodle.
5. Only one submission per team.

Evaluation Rubrik

Your evaluation will be based on

- Demosaiking - 2 points
- Night-time image enhancement - 2 points
- Foggy image enhancement - 2 points
- Working with different color spaces - 1 point
- Video quality enhancement - 2 points
- Report + demo - 1 point

References

[1] H. S. Malvar, L.-w. He, and R. Cutler, "High-quality linear interpolation for demosaicing of bayer-patterned color images," in *2004 IEEE International Conference on Acoustics, Speech, and Signal Processing*, vol. 3. IEEE, 2004, pp. iii–485.