HOMEWORK ASSIGNMENT 1
Image Enhancement and Noise Removal

Due Date: 11:59 p.m. on Mar. 19, 2024
Please read the **submission guideline** carefully before getting started. All images in this homework are in PNG format and can be downloaded from our NTU COOL website. Details of all files offered are listed in the appendix. You are **NOT** allowed to use other functions except I/O, plotting and basic functions.

Problem 0: WARM-UP

The goal of this problem is to get familiar with fundamental operations for image processing.

sample1.png

(a) (`5 pt`) Perform vertical flipping on **sample1.png** and output the result as **result1.png**.

(b) (`5 pt`) Transforming a color image to grayscale is a fundamental task in digital image processing and computer vision. Please generate a grayscale version of **result1.png** and save it as **result2.png**.

Note: the built-in functions such as `cv2.cvtColor()` to directly perform transformation are NOT allowed.

Problem 1: IMAGE ENHANCEMENT

Given two gray-level images **sample2.png** and **sample3.png**. Please follow the instructions below to create several new images.

(a) (`5 pt`) Decrease the brightness of **sample2.png** by dividing the intensity values by 3 and output the result as **result3.png**.

(b) (`5 pt`) Increase the brightness of **result3.png** by multiplying the intensity values by 3 and output the result as **result4.png**.

(c) (`10 pt`) Plot the histograms of **sample2.png**, **result3.png** and **result4.png**. What can you observe from these three histograms?

(d) (`15 pt`) Perform global histogram equalization on **sample2.png**, **result3.png** and **result4.png**, and output the results as **result5.png**, **result6.png** and **result7.png**, respectively. Please compare these three resultant images and plot their histograms.

(e) (`10 pt`) Perform local histogram equalization on **sample2.png**. Output the results as **result8.png** and plot its histograms. Compare and discuss the results of global and local histogram equalization.

(f) (`15 pt`) TA's cat is playing hide and seek and seems to be missing! Please design a transfer function to enhance **sample3.png** and output the result as **result9.png**. Try your best to obtain the most appealing result by adjusting the parameters. Show the parameters, the best resultant image and its corresponding histogram. Provide some discussions on the result as well.

sample2.png

sample3.png

Problem 2: NOISE REMOVAL

Given an original image named **sample4.png** and two images corrupted by noise as shown in **sample5.png** and **sample6.png**, please follow the instructions below. Additionally, please consider **sample7.png** as a bonus.

(a) (`20 pt`) Design different filters to remove the noise in **sample5.png** and **sample6.png**. Output the clean images as **result10.png** and **result11.png**, respectively. Write down details of your noise removal process in the report, including the filters and parameters used, along with discussions on their selection rationale.

(b) (`10 pt`) In noise removal problems, PSNR is a widely used metric to present the quality of the recovered image. Please compute PSNR values of **result10.png** and **result11.png**, respectively, and provide some discussions.

$$PSNR = 10 \times \log_{10}(\frac{255^2}{MSE}), MSE = \frac{1}{w \times h} \sum_{j} \sum_{k} [F(j,k) - F'(j,k)]^2$$

(c) (`bonus`) Design an algorithm to remove the noise from **sample7.png**. Output the clean image as **result12.png**. Additionally, calculate the PSNR value of the resultant image. Provide the details of your noise removal process in the report, and provide some discussions regarding to the result.

Note: The built-in functions such as `cv2.gaussianblur()` to directly blur image are NOT allowed.
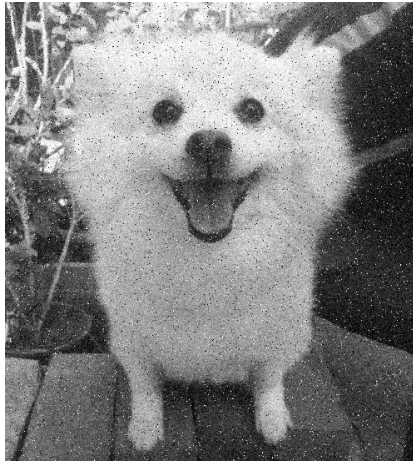

sample4.png

Figure 1: Original image.

sample5.png

sample6.png

Figure 2: Noisy images.

sample7.png

Figure 3: Mixed noise.

Appendix

Problem 0: WARM-UP

sample1.png: 800×650 color

Problem 1: IMAGE ENHANCEMENT

sample2.png: 800×600 gray-scale

sample3.png: 600×800 gray-scale

Problem 2: NOISE REMOVAL

sample4.png: 550×500 gray-scale

sample5.png: 550×500 gray-scale

sample6.png: 550×500 gray-scale

sample7.png: 550×500 gray-scale