2022 NYCU Digital Image Processing - Homework 2 Report

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1 Contrast Enhancement

Contrast is the distinction between lighter and darker areas of an image, and it refers to making it more obvious the objects or details within an image more. Contrast Enhancement is an image processing technique that aims at enhancing the global or local contrast of an image. In this exercise, I use two methods to enhance the contrast of the input image, which are *gamma correction* and *histogram equalization (HE)*.

- **Gamma Correction**

The gamma correction method is used to improve image quality through contrast adjustment. It is a method that allows controlling the brightness of an image. The formula used to get gamma corrected image is given below:

$$O = \left(\frac{I}{255}\right)^{\frac{1}{\gamma}} \cdot 255$$

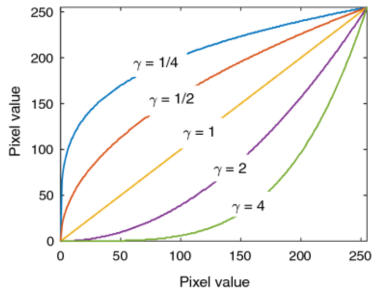


Figure 1: Gamma Correction

I: input pixel value [0, 255].
O: output pixel value [0, 255].
γ: gamma that controls image brightness. (gamma < 1: darker, gamma = 1: no effect, gamma > 1: lighter)

Because the brightness of the whole original image (input1) is too high. So, I choose gamma = 0.5 to make dark areas darker and keep the bright areas the same to enhance the details of the image.

- **Histogram Equalization (HE)**

Histogram equalization is a method of image processing of contrast adjustment using the image's histogram. To enhance the image contrast it spreads out the most frequent pixel intensity values or stretches out the intensity range of the image. The objective of this method is to give a linear trend to the cumulative probability function associated with the image.

To implement histogram equalization. First, we need to find the histogram of the image. The histogram of an image is a distribution of its discrete intensity level in the range [0, 255]. The distribution is a discrete function associated with each intensity. In practice, it is to scan the entire image and count the different intensities of each channel. The processing of histogram equalization relies on the use of the cumulative probability function (CDF). The cumulative sum of the probabilities lying in its domain and defined by:

$$\mathrm{CDF(x)} = \sum_{k=0}^{255} P(k)$$

Then, multiply the CDF by the expected value of 255 to get the transformation of input intensity to the output intensity. Finally, covert each input pixel to get a new output pixel.

$$I_{out} = 255 \times \mathrm{CDF}(I_{in})$$

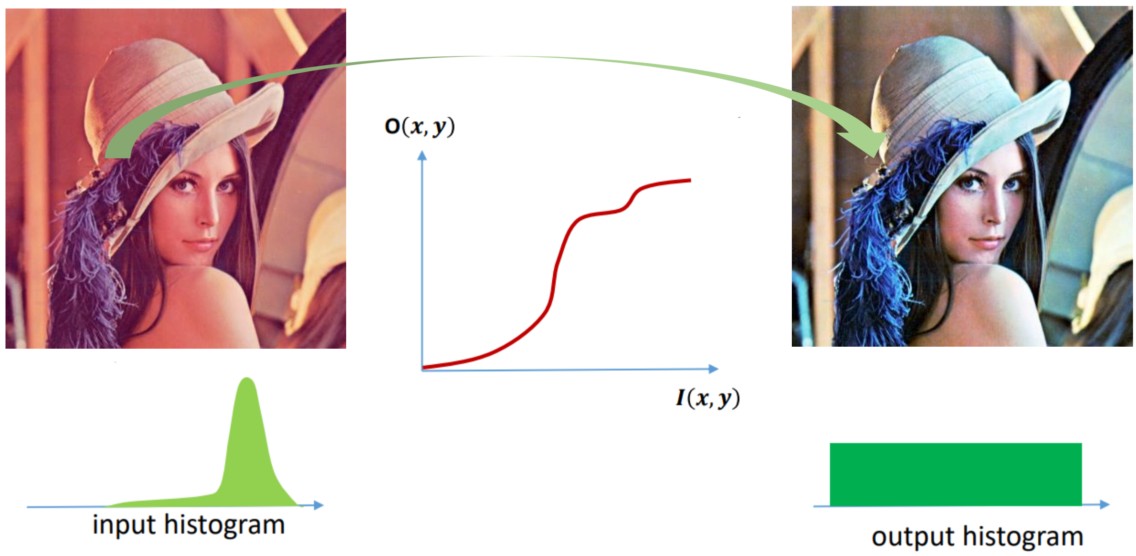


Figure 2: Histogram equalization

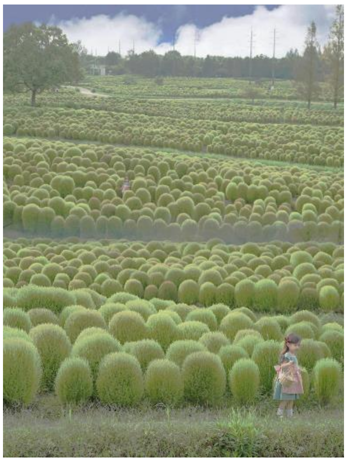
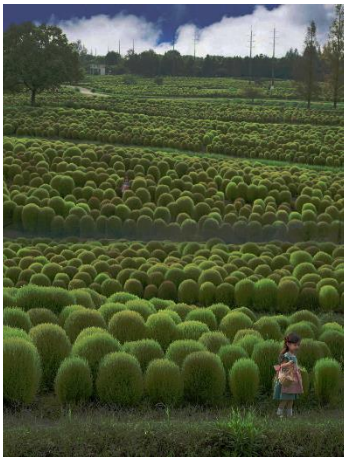
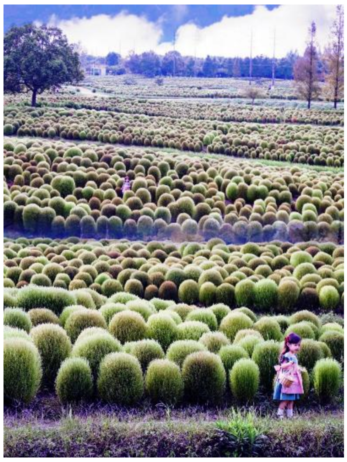
	Original	Gamma Correction (gamma = 0.5)	Histogram Equalization
input1			
lena			

Table 1: Result of contrast enhancement

2 <u>Sharpness Enhancement</u>

Sharpness enhancement is a technique for a digital image to give a sharper appearance. Sharpening enhances the definition of edges in an image. The sharpened image is that in which the edges are clearly distinguishable by the viewer. In this exercise, I use the Laplacian filter to enhance the sharpness. The Laplacian filter is a 2-D isotropic measure of the 2nd spatial derivative of an image.

- **Laplacian Filter**

The Laplacian *L(x, y)* of an image with pixel intensity value *I(x, y)* is given by:

$$L(x,y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$$

This can be calculated using a convolution filter. Since the input image is represented as a set of discrete pixels, we have to find a discrete convolution kernel that can approximate the second derivatives in the definition of the Laplacian. For the implementation, I choose to use a composite Laplacian mask as a kernel.

-1	-1	-1
-1	9	-1
-1	-1	-1

In order to avoid the image will keep getting smaller during the convolution process, I use replication padding to fill the border with the value same value as the border pixel. To make two distinct sharpness enhancements, I set the number of iterations to produce two results.

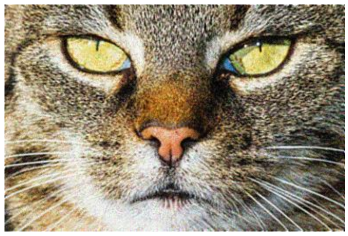
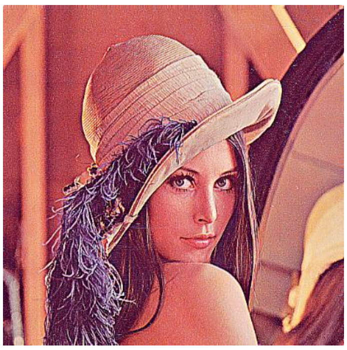
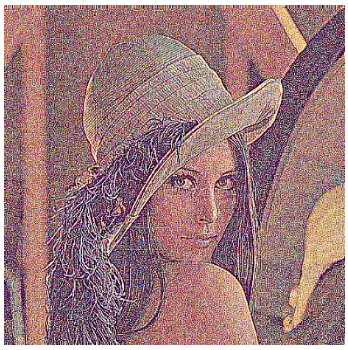
	Original	**Laplacian Filter (iteration = 1)**	**Laplacian Filter (iteration = 2)**
input2			
lena			

Table 2: Result of sharpness enhancement

3 <u>Denoise</u>

Image denoising is removing noise from a noisy image. In this exercise, the input image adds a lot of Gaussian noise. So, I use the Gaussian filter to reduce the noise of the input image. The 2D Gaussian kernel follows the below given Gaussian distribution.

$$G(x, y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Where y is the distance along the vertical axis from the origin, x is the distance along the horizontal axis from the origin and σ is the standard deviation. For the implementation, I used a 3x3 Gaussian filter to reduce the background noise.

$$\frac{1}{16} \times \begin{array}{|c|c|c|} \hline 1 & 2 & 1 \\ \hline 2 & 4 & 2 \\ \hline 1 & 2 & 1 \\ \hline \end{array}$$

Likewise, to avoid the image being smaller, replication padding is added, too. At two different levels of denoise, one with 10 iterations and the other with 40 iterations. The more iterations, the blurrier the image. At the same time, it will also reduce the more Gaussian noise.

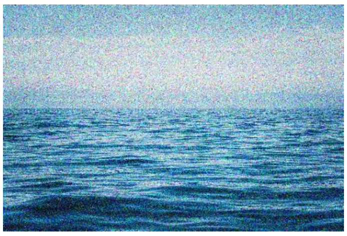
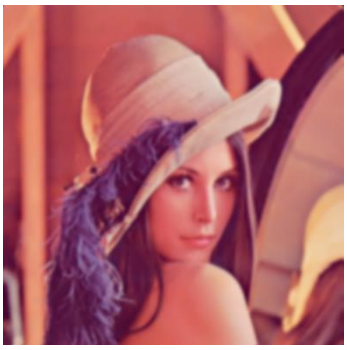
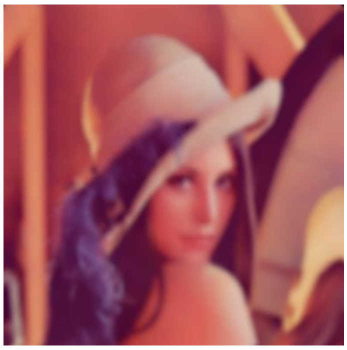
	Original	**Gaussian Filter (iteration = 10)**	**Gaussian Filter (iteration = 40)**
input3			
lena			

Table 3: Result of denoise