EE5806: Topics in Digital Imaging Processing
2022-23: Semester A
Assignment 1

Instructions:
Students must submit the assignment through Canvas. Click on the item "Assignment" on the left panel. You should see a row with title "Assignment 1". Click on the "Assignment 1" label. You can then see detailed instructions for submission. Please submit a report in Microsoft word format containing printouts of any code and figures requested in each of the problems. The report should also contain answers to all questions. Please also save your code and submit them as separate text files with .py extension as requested in the questions. **Your report and all the requested .py files should be zipped as a single zip file for submission.** When you are ready to submit the assignment, click on the "Submit Assignment" label on the right panel and upload the requested zip file.

Problem 1 (25 marks)
Fig. 1 shows a point operation $D_B = kD_A^2$, where k is a constant. Answer the following questions:

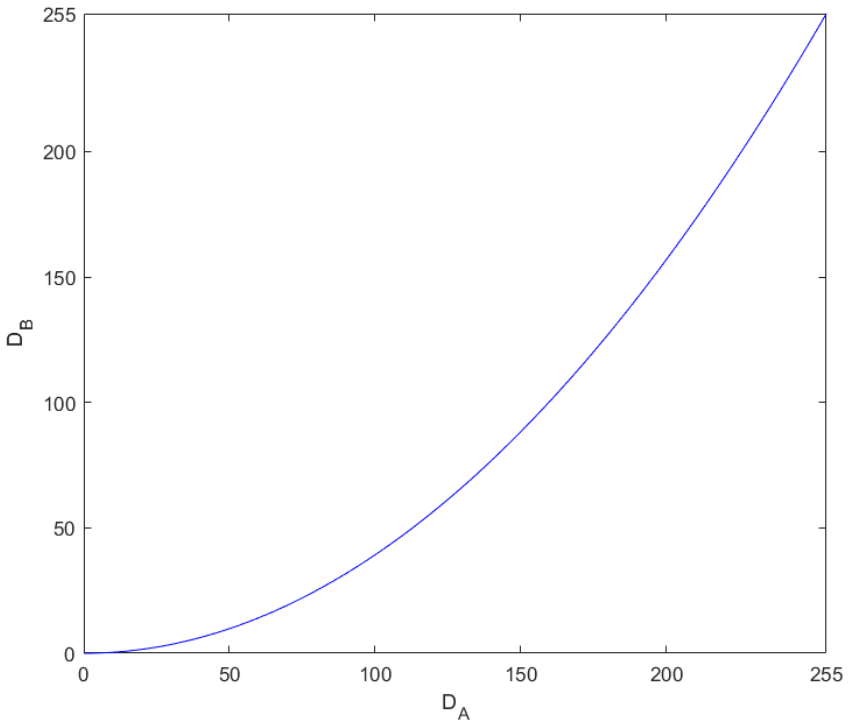

Figure 1 Point Opration Plot for Problem 1

(a) Determine k.
(b) Find the expression for $H_B(D_B)$ in terms of H_A and D_B.
(c) Find the expression for $H_B(D_B)$ if

$$H_A(D_A) = \frac{1}{255} \quad \forall D_A.$$

Problem 2 (30 marks)

(a) Given that D_m=255 and the total number of pixels of Image A is A_0. Determine and plot the point operation, $f_1(D_A)$, that flattens H_A for the whole range of D_A (i.e., $0 \leq D_A \leq 255$) if H_A, the histogram of an image with continuous gray level, is given by

$$H_A(D_A) = \frac{2A_0 D_A}{D_M^2}$$

(b) Determine and plot the point operation, $f_2(D_C)$, that flattens H_C, the histogram of Image C, for the whole range of D_C (i.e., $0 \leq D_C \leq 255$) if

$$H_C(D_C) = k\left(D_C - \frac{255}{2}\right)^2$$

where k is a constant. Please also compute k in terms of A_0.

(c) Determine the point operation that converts H_A to H_C.

Problem 3 (20 marks)

Given a 3-bit image with the following histogram,

D_A	$H_A(D_A)$
0	609
1	3298
2	2150
3	3979
4	312
5	1768
6	426
7	3842

(a) Find a point operation (in tabular form) that will match it to the following histogram.

D_C	$H_C(D_C)$
0	0
1	0
2	4096
3	4096
4	4096
5	4096
6	0
7	0

(b) Compute the histogram of the output image. Compare the output histogram of your point operation with the desired histogram. Does the output image has the desired histogram? Why or why not?

Problem 4 (25 marks)

Given the matrices representing the image I and the computational molecule H:

$$H = \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}, \qquad I = \begin{bmatrix} 1 & 5 & 9 & 13 \\ 2 & 6 & 10 & 14 \\ 3 & 7 & 11 & 15 \\ 4 & 8 & 12 & 16 \end{bmatrix}$$

(a) Write a Python script called `corrtest.py` that computes $I_0 = I \star H$ (i.e., the correlation operation between I and H). The output should have the same size as I and the boundary should be handled by the 'reflect' option. Hint: use the built-in function `scipy.ndimage.correlate()`.

(b) Compute $I_0(0,0)$ and $I_0(3,3)$ by manual calculation and verify that your manual calculation results match those generated by the Python program.

(c) Write a Python function called `BoxcarZeroPadding` that filters an image with a $k \times k$ boxcar filter. The boundaries are handled by zero-padding. The function header should have the form and return the filtered image:

```
def BoxcarZeroPadding(image, k)
```

where `image` is an 8-bit image and `k` represents the size of the boxcar computational molecule. You can use all Python built-in functions except `skimage.filters.rank.mean()`.

(d) Write a Python script called `TestBoxcarZeroPadding.py` that filters the image "characterTestPattern688.tif" with k=35 using `BoxCarZeroPadding()`. The script should contain code that plots the input and output.

(e) What do you observe about the boundary of the output? Explain your observation.