

Concordia University

Department of Computer Science & Software Engineering

COMP 478/6771 Image Processing

Assignment 1 - Due Date: *October 1, 2024*

Part I: Theoretical questions

1. **(5 points)** Given two arbitrary images $f(x,y)$ and $g(x,y)$ and two arbitrary constant a and b , H is said to be a linear operator if:

$$H [af(x,y) + bg(x,y)] = aH [f(x,y)] + bH [g(x,y)]$$

The median m of a set of numbers is such that half the values in the set are below m and the other half are above it (the mid-point value by population). Is an operator that computes the median of a set of pixels of a sub-image area linear or nonlinear? Explain your answer by giving examples.

2. **(20 points)** The purpose of this question is to perform histogram equalization to a given histogram and plot the resulting histogram. Given the following histogram where **GL** is Gray level, and **NP** is Number of pixels:

GL	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NP	0	5	13	57	100	39	21	12	7	2	0	0	0	0	0	0

- a) **(5 points)** Plot the histogram of the image given in the table above.
- b) **(10 points)** Let r_k be the GL given in the table, perform histogram equalization by:
- Calculate s_k from the table.
 - Plot the probability density functions $p_r(r_k)$ and $p_s(s_k)$.
- c) **(5 points)** Plot the new histogram after performing the histogram equalization.
3. **(5 points)** The Given two images $f(x,y)$ and $g(x,y)$ with histogram h_f and h_g . Assuming that all the pixels of image $g(x,y)$ have the same intensity equal to a non-zero positive constant value c . The gray levels of the pixels of both images have positive values. Please explain the relationship between the histograms of $f(x,y)$ and the new images formed by $f(x,y) + g(x,y)$ and $f(x,y) * g(x,y)$

Part II: Programming questions

1. Download the image *HawkesBay.jpeg* from the assignment folder and perform the following operations using MATLAB or any software packages that support similar functionalities (*some minor differences may exist*). Please show your steps in the report.
 - 1) **(1 point)** Write a script to read the grayscale of the image.
 - 2) **(3 points)** Write a program to calculate the histogram of the image and display the histogram chart.
 - 3) **(2 points)** Compare the calculated histogram obtained by using your own program with the one using the **imhist** function in MATLAB (*exposure.histogram()* in scikit-image).
 - 4) **(3 points)** Write a program to do histogram equalization on this image and show the result.
 - 5) **(1 point)** Compare the histogram-equalized image obtained by using your own program with the one by using **histeq** function in MATLAB (*exposure.equalize_hist()* in scikit-image).
2. In class, we have demonstrated the visual illusion of the hybrid image, which displays different image content depending on the distance or scale the image is viewed. In this question, we will make one with the spatial filters introduced in class. Please follow the steps below:
 - 1) **(1 point)** Write a script to read the images, *einstein.bmp* and *marilyn.bmp*, and convert them into grayscale images using the function *rgb2gray()* (same function name in MATLAB and scikit-image).
 - 2) **(3 points)** Write a script to create an unsharp mask for the grayscale image of Einstein. For image blurring, please use a box filter of size 11x11. You can use the function *imboxfilt()* in MATLAB (*uniform_filter()* in scikit-image). Please showcase the result in the report.
 - 3) **(2 points)** Write a script to filter the grayscale image of Marilyn with a box filter of size 11x11 and showcase the result in the report.
 - 4) **(2 points)** Add the post-processed images of Einstein and Marilyn in Step 2 and 3 together and demonstrate the hybrid image in two different scales to visualize different contents in the image in the report.