Assignment #2

Contrast Enhancement!

How TA evaluates your assignments:

Report: half of your score will be graded proportional to the quality of your report. You should provide a distinct section for each problem, include the desired outputs and explain what you've done. Don't forget to discuss your results as well. Note that in your reports, all your figures must have captions. It is not necessary to accommodate your source codes in your reports unless you want to refer to them. Compactness, expressiveness and neatness are of high importance.

Source Code: create an m-file for any problem and write all your codes there. If a problem consists of several sub-problems, separate them by comments in your code. Finally, name your m-files according to the number of the problems.

For evaluating your codes, TA creates two empty folders just beside your m-files, named as "input" and "output" (in the same directory). Then, he copies the input materials into the "input" folder and executes your m-files. Next, the output files will be checked in the "output" folder. Therefore, write your codes so as to load input files from an "input" folder and save the output files in an "output" folder. The exact name of the input and output files will be provided in the problem descriptions.

You can use MATLAB built-in functions in your implementations except for the cases in which the allowance has been explicitly revoked.

What to hand in:

You must submit your report (.pdf), source codes (m-files) and output files for each assignment. Zip all your files into an archive file and use the following template to name it:

HW2_XXXXX.zip

where XXXXX must be replaced with your student ID. Your file size must not be bigger than 20MB. If there is any question, don't hesitate to contact us through nasiri.hamid@gmail.com, s.izadi@live.com

The Due Date for This Assignment is: April 8Th

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1. Contrast stretching is a simple image enhancement technique that attempts to improve the contrast in an image by stretching the range of intensity values it contains to span a desired range of values.

a. Load the image "wom.jpg" and depict its 256-bin histogram. As you know, the contrast of the provided image is weak. Justify this fact according to the form of the histogram.

b. The simplest form of contrast stretching can be applied by using the following expression to calculate the new pixel value of each pixel:

$$p_{out} = (p_{in} - c)\left(\frac{b-a}{d-c}\right) + a$$

where a and b are the lower and upper limits of the image (say 0 and 255). In addition, c and d are the lowest and highest pixel values currently present in the image. p_{out} and p_{in} are the output and input pixel values for any element. Values below 0 are set to 0 and values about 255 are set to 255. Write a program to apply the preceding normalization expression on each pixel. Depict the histogram of the resultant image and discuss your observations. Compare the histograms of the image before and after operation. Name the resultant image as "wom_strech.bmp" and write it into the output directory. You are not allowed to use MATLAB built-in functions for contrast stretching.

c. What is the probable problem with setting c and d equal to the lowest and highest pixel values of the image? (Hint: outlier). To overcome this issue, scrutinize the image histogram and select different values for c and d. Re-execute the program with new values and include the best result in your report

(Hint: the 5th and 95th percentile in the histogram may be good choices).

d. Imagine you have an image taken in low light levels and which, as a result, has low contrast. What are the advantages of using contrast stretching to improve the contrast, rather than simply scaling the image by a factor of, say, three?

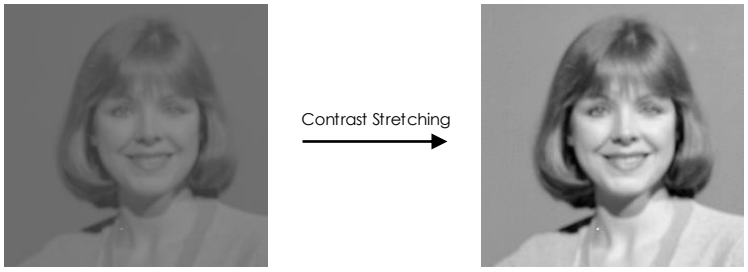

Figure 3. Contrast Stretching

The dynamic range of an image can be compressed by replacing each pixel value with its logarithm. This has the effect that low intensity pixel values are enhanced.

e. Load the image "man.jpg" and depict its 256-histogram. What can you infer from the raw image and its histogram?

f. Apply logarithm operator to the image and depict the histogram of the resultant image. Name the output as "man_log.bmp" and write it into the output directory. Discuss your observations. Does the operator enhance the image? Why?

g. Load the image "svs.jpg" and apply the logarithm operator upon it. Include the results and its histogram in your report. Does it improve the image contrast? Why?

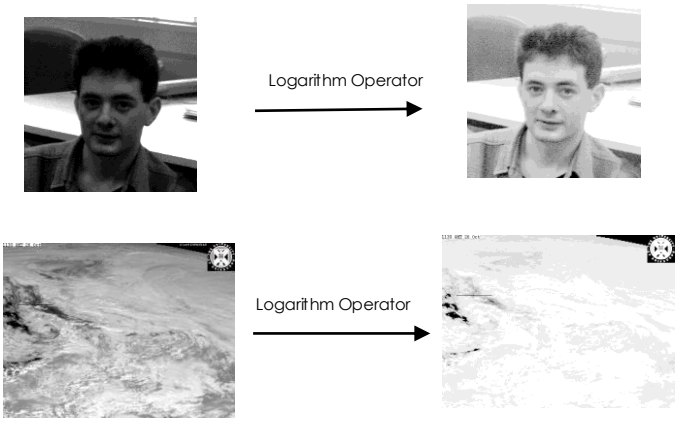

Figure 4. Logarithm Operator

2. Equalize the histogram of the 8 × 8 image below. You should not use MATLAB, instead calculate it by hand. The image has grey levels 0, 1,..., 7. You can either type your solution or scan your handwritten solution. Include all the arithmetic details in your solution.

$$\begin{matrix} 6 & 4 & 4 & 4 & 4 & 4 & 4 & 0 \\ 6 & 5 & 5 & 5 & 5 & 5 & 4 & 0 \\ 6 & 5 & 7 & 7 & 6 & 5 & 4 & 0 \\ 6 & 5 & 7 & 7 & 6 & 5 & 4 & 0 \\ 6 & 5 & 7 & 7 & 6 & 5 & 4 & 0 \\ 6 & 5 & 5 & 5 & 5 & 5 & 4 & 4 \\ 6 & 4 & 4 & 5 & 4 & 4 & 4 & 4 \\ 6 & 4 & 4 & 5 & 4 & 4 & 4 & 4 \end{matrix}$$

3. In this problem you are supposed to get through histogram calculation. Provide complete solutions for the following problems.

a. Write a program to calculate 256-bin histogram of an image. Your code should be as efficient as possible, and thus avoid using to many nested loops in your implementation! Apply your code on at least two arbitrary images and display the results.

b. Delve into the MATLAB function 'imhist()'. Analyze its arguments and provide a brief report on the functionality of this command.

c. Compare the results of your code with those of MATLAB function 'imhist()'. Compare the results using MATLAB function 'isequal()'. Technically, there should not be any difference between the results, otherwise explain the reason(s).

4. Histogram Equalization is one of the oldest methods to enhance the contrast in an image. Generating codes for carrying our histogram equalization can further fit the concept in your minds. Accordingly:

a. Write a program to perform histogram equalization. Your code should be as efficient as possible, hence make effort to exploit tricks available in MATLAB for boosting time-efficiency of your code. Apply your code on two arbitrary gray-level images.

b. See the MATLAB function 'histeq()' for histogram equalization. What arguments it receives? Provide a brief report on the functionality of this function.

c. Compare the results of histogram equalization from your code and those of 'histeq()'. Is there any difference? If yes, explain why.

d. Explain what is the best way to apply histogram equalization on color (RGB) images. Implementation will give you **10 bonus pts.**

5. Write a program to match the histograms of two images. Specifically, your program must receive two images, namely img#1 and img#2, and match the histogram of img#1 to that of img#2. Verify your implementation on images 'pigeon.jpg' and 'soldier.jpg' as img#1 and img#2 respectively. Display the histograms and corresponding gray-scale images. Discuss the resultant images.

6. In this problem you are supposed to solve some filtering task by your hand. You are not allowed to use MATLAB or any other programming software. You can either type your solution or scan it.

a. Spatially filter (convolve) the image on the left with the 3 x 3 mask (kernel) shown. State the assumptions you make for the pixels outside the source image.

0	0	0	0	0
0	0	1	0	0
0	1	2	1	0
0	0	3	0	0
0	0	0	0	0

Input Image

*

1	2	1
2	4	2
1	2	1

Mask

=

Output Image

b. What is the result of mean filtering (averaging pixels with their 8-connected neighbors) for the following image?

10	11	9	25	22
8	10	9	26	28
9	99	9	24	25
11	11	12	23	22
10	11	9	22	25

Input Image

Output Image

c. What is the result of median filtering (using 8-connected neighbors) for the following image?

10	11	9	25	22
8	10	9	26	28
9	99	9	24	25
11	11	12	23	22
10	11	9	22	25

Input Image

Output Image

d. What is the result of unsharp masking using an A = 1 (a 5 in the center) mask?

10	11	9	25	22
8	10	9	26	28
9	8	9	24	25
11	11	12	23	22
10	11	9	22	25

Input Image

Output Image

7. Detection can be implemented by computing the correlation between a template and an image. The image location that have the maximum correlation value can be interpreted as object detections. Visualize the correlation results and the locations where the object is detected (generating a binary map is a good idea in which the object are set to one and zero elsewhere). This technique is known as Template Matching in the literature.

a. Apply template matching using any normalized cross-correlation (NCC)

i. to face1.pgm and its feature templates eye1.pgm, nose1.pgm, and mouth1.pgm.

ii. to face2.pgm and its feature templates eye2.pgm, nose2.pgm, and mouth2.pgm.

b. Apply template matching using the same normalized cross-correlation chosen in part (a):

i. to face1.pgm and the templates eye2.pgm, nose2.pgm, and mouth2.pgm.

to face2.pgm and the templates eye1.pgm, nose1.pgm, and mouth1.pgm.

c. Display and discuss the matching results.

d. Repeat the experiments above by using the SSD (Sum_of_Squared_Differences) method. Display and discuss the matching results.

e. Describe briefly how you dealt with the border issue.

f. Compare the NCC and SSD methods.

File: face1.pgm

File: face2.pgm

File: eye1.pgm File: nose1.pgm File: mouth1.pgm File: eye2.pgm File: nose2.pgm File: mouth2.pgm

8. Read the following *Wikipedia* page and submit an informative and compact documentation. Your documentation should include all fundamental concepts in the page. You may also use extra resources to enrich your documentation. The summary is supposed to be at least one complete **A4** page with **B Nazanin 12** font. **The space between lines should be 1.00** and **margin of the pages** must be kept by the **default value** in MS Office.

Color Balance https://en.wikipedia.org/wiki/Color_balance

9. Apply the following filters on the image "snake.jpg". Name the resultant images as "snake_a.jpg" to "snake_p.jpg" and write them into the output directory. Explain and justify the effect of each filter according to its result. You can use built-in MATLAB functions in this problem.

$1/9$	$1/9$	$1/9$
$1/9$	$1/9$	$1/9$
$1/9$	$1/9$	$1/9$

(a)

$1/18$	$1/18$	$1/18$
$1/18$	$1/18$	$1/18$
$1/18$	$1/18$	$1/18$

(b)

$1/7$	$1/7$	$1/7$
$1/7$	$1/7$	$1/7$
$1/7$	$1/7$	$1/7$

(c)

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

(d)

-1	-1	-1
-1	18	-1
-1	-1	-1

(e)

0	-1	0
-1	5	-1
0	-1	0

(f)

1	0	0
0	0	0
0	0	-1

(g)

0	0	-1
0	0	0
1	0	0

(h)

0	1	0
0	0	0
0	-1	0

(i)

0	0	0
-1	0	1
0	0	0

(j)

1	1	1
1	-8	1
1	1	1

(k)

-1	-1	-1
0	0	0
1	1	1

(l)

-1	-1	-1
0	1	0
1	1	1

(m)

-1	0	0
0	2	0
0	0	-1

(n)

0	0	-1
0	2	0
-1	0	0

(o)

	$1/3$	0
0	$1/3$	0
0	$1/3$	0

(p)

10. Load the image "skeleton.jpg". In this problem you have to sharpen the provided image and bring out more skeletal detail. There are two problems with the provided image: first, the dynamic range of the image is too narrow and second, high noise content makes the image difficult to enhance. As you learned in the class, one way to overcome these issues is to exploit a combination of spatial enhancement methods.

a. Implement the strategy which was presented in the class and discuss the advantage of each step. Name the result as "skeletol_combine.bmp" and write it into the output directory.

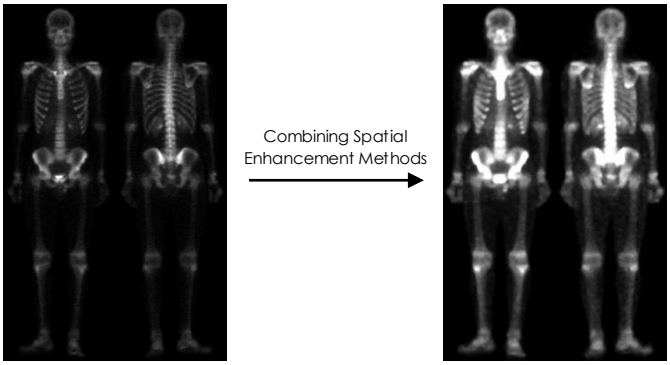

Figure10. Combining Spatial Enhancement Methods

Good Luck,

Hamid Nasiri,

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