Digital Image Processing
School of Information Science and Technology
ShanghaiTech University

Assignment 1

Due time: 23:59, March 15th, 2023

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1 Notes

This homework has **100 points** in total.

Please submit your homework to blackboard with a zip file named as **DIP2023_ID_Name_hw1.zip**. The zip file should contain three things: **a folder named 'codes' storing your codes**, **a folder named 'images' storing the original images**, and **your report named as report_ID_Name_hw1.pdf**. The names of your codes should look like **'p1a.m'** (for (a) part of Problem 1), so that we can easily match your answer to the question. Make sure all paths in your codes are relative path and we can get the result directly after running the code. Please answer in English.

Please complete all the coding assignments using MATLAB. All core codes are required to be implemented by yourself (without using relevant built-in functions). Make sure your results in the report are the same with the results of your codes. Please explain with notes at least at the key steps of your code.

2 Policy on plagiarism

This is an individual homework. You can discuss the ideas and algorithms, but you can neither read, modify, and submit the codes of other students, nor allow other students to read, modify, and submit your codes. Do not directly copy ready-made or automatically generated codes, or your score will be seriously affected. We will check plagiarism using automated tools and any violations will result in a zero score for this assignment.

3 Problem sets

Problem 1 (30 pts)

$$\begin{bmatrix} 6 & 1 & 2 & 1 & (2) \\ 2 & 3 & 5 & 3 & 8 \\ 1 & 0 & 1 & 2 & 3 \\ 3 & 2 & 4 & 5 & 2 \\ (1) & 5 & 3 & 4 & 0 \end{bmatrix}$$

(a) Calculate the D_4, D_8, D_m distance between the pair of points(framed in parentheses) in the matrix above, mark the shortest 4-,8-,m-path respectively. Show the results in your report. (V=1,2,3) (10 pts)

(b) An affine transformation of coordinates is given by

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = A \begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

Please perform the following transformation on **jetplane.tif**, write out the affine transformation matrix, then show the results:

(1) Scaling and shearing. Set x-scaling factor to 2 and y-scaling factor to 3, then shear the image horizontally 4 units. (5 pts)

(2) Translation and Rotation. Move 2 units to the left and move down 5 units, then rotate 45 degrees clockwise (about the origin). (5 pts)

(Hint: The main focus of this problem is to solve the affine transformation matrix, and using built-in functions like imwarp() to obtain the transformed image is allowed.)

(c) Perform bit-plane slicing on **lena_gray_256.tif** to get bit plane 1-8 and show the results in your report. Which kind of bit-plane usually contains more effective information, low bit or high bit? Why? (10 pts)

Solution:

Problem 2 (30 pts)

(a) Compute the histogram of **einstein_low_contrast.tif**. Perform histogram equalization (HE) on it, show the result. Show the histogram of the processed image, too. Why can HE enhance the contrast? (10 pts)

(b) Match the histgram of **lena_color.tif** to **peppers_color.tif**. Show the result in your report. (8 pts)

(c) Perform contrast limited adptive histogram equalization(CLAHE) on **man_in_house.png**. Contrast the result to HE method. Show the results in your report. Explain why CLAHE has a better effect.(Reference: http://cas.xav.free.fr/Graphics%20Gems%204%20-%20Paul%20S.%20Heckbert.pdf, page474-485) (12 pts)

(Hint: If you can effectively eliminate the checkerboard effect and balance the efficiency of the algorithm, you will get a bonus. Built-in functions like hist(), histogram(), histeq() and adapthisteq() are not allowed.)

Solution:

Problem 3 (40 pts)

(a) Implement full convolution and cropped convolution of the given matrices, show the results in your report. (8 pts)

$$\begin{bmatrix} 6 & 4 & -1 & 0 & 1 \\ 1 & -3 & -4 & 3 & 2 \\ 0 & 3 & 5 & -2 & 1 \\ 9 & -1 & -3 & 4 & 5 \\ -2 & -5 & 2 & 3 & 0 \end{bmatrix} \quad \begin{bmatrix} 1 & 2 & 4 \\ -3 & -1 & 1 \\ 5 & 2 & -1 \end{bmatrix}$$

(Hint: Pay attention to the difference between convolution and correlation.)

(b) Describe the noise type on **circuitboard-a.tif**, **circuitboard-b.tif**, **circuitboard-c.tif** and **circuitboard-d.tif**, then choose the best filter you think for each of them to reduce the noise. Show the results in your report. (12 pts)

(Hint: Choose the best kernel size you think.)

(c) Filter the image **house.tif** in both x direction and y direction with 3*3 Sobel mask and Laplacian mask. Show the results in your report. (8 pts)

(d) Perform image sharpening on **house.tif** using LoG filter(with the $\sigma^2 = 1$ and another two values you choose yourself) and unsharpen mask method(choose the best k you think). Show the results in your report. (12 pts)

Solution: