بسم الله الرحمن الرحیم

University of Tehran
College of Engineering

Digital Image Processing

Instructor: Dr. Hamid Soltanian-Zadeh

Homework Assignment 4:

Image Restoration and Reconstruction

Due date: 1404/1/27

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1 Instructions

Please answer the following questions based on Chapter 5 (*Image Restoration and Reconstruction*) of the textbook by Gonzalez and Woods. Submit your solutions by the due date. Read the following carefully and follow these instructions when submitting your answers:

Requirement	Description	Consideration
Standard Due Date	1404/1/27- 23:59	
Elearn HW Upload	**Only**	Only use ELearn to submit your homeworks.
Email Address	adanayidet@gmail.com	Feel free to say hello!
Submit format	Read Note 4	Extremely important
Late Submit	Penalty	$5 - 10\%$ penalty per day

Note 1: *This request is not intended to impose any hardship on you, but to help with better management of the class. Your cooperation is greatly appreciated in making the process more efficient. Thank you!*

Note 2: *We will also have a Telegram group for Q&A. The link (clickable) is provided here:* [open the link]

Note 3: *Use camera scanners if you wish to submit your handwritten answers. While readability is always important, it is especially critical in the DIP course, which focuses on quality enhancement.*

Note 4: *You must send a zip or rar file named* `DIP-HWx-std.no` *where x is the number of the homework (e.g.* `DIP-HW4-810199034`*). Inside the zipped file will be a folder for each question containing its code and output images. There should also be a single pdf file in the root folder as your main report.*

Academic Integrity: *Plagiarism, cheating, or using unauthorized external resources (including AI tools, solution manuals, or copying from peers) is strictly prohibited. All assignments will be checked for originality, and any violations will result in academic penalties. Please submit only your own work.* ***It's easy to detect whether your answers are generated by AI or are truly your own work, so be sure to submit original solutions.***

2 Noise Reduction in Satellite Imagery

Background

Satellite images often suffer from noise due to atmospheric interference, sensor limitations, and transmission errors. Effective noise reduction methods are crucial for improving image clarity in remote sensing applications.

a. Apply three different noise reduction filters (Mean, Median, and Gaussian). Which one is more effective? How can you discuss "Effectivess"?

b. Analyze how each filter affects edge preservation. Which one is the most suitable for maintaining image details?

c. If the noise follows a Gaussian distribution, how would Wiener filtering perform compared to the above methods? Implement and compare.

d. Explore how adaptive filtering techniques could improve the results. Implement an adaptive median filter and compare the output.

3 Deblurring in Medical Imaging

Background

Medical images, such as MRI or PET scans, often suffer from blurring due to motion artifacts or imperfect imaging conditions. Image deblurring techniques are used to restore sharpness. Here we have MRI images in `images/q3` folder as `1.img`, `2.img` and `3.img`. As you see, all three images are degraded and blurring is happened. An expert takes two of the degraded samples and tries to solve the blurring problem by experimenting an image processing software. The results are given in `1_ideal.img` and `2_ideal.img`.

a. Based on the recovered images given to you by the expert, try to find out the degradation transfer function. Since you have two set of images, you will extract two possibly different functions. As an extra point, you can find a way to find a better single transfer function by utilization of both sets.

b. Use Inverse Filtering to restore the image. Discuss its limitations when noise is present.

c. Apply Wiener Filtering for deblurring and compare it with the inverse filter.

d. Discuss the trade-off between noise amplification and sharpness enhancement in deblurring techniques.

4 Image Restoration Under Fog

Background

In real-world outdoor imaging, environmental factors such as fog and haze often degrade image quality by reducing contrast and introducing a diffuse glow over the scene. These distortions blur fine details and flatten depth cues, making it difficult to analyze or enhance such images. In this exercise, we aim to restore a foggy image using the Constrained Least Squares Method, which incorporates knowledge of both the degradation function and noise characteristics to achieve improved restoration. The image is given in `images/q4`.

a. Use the Constrained Least Squares Method to restore the given image. Explain how you estimated the degradation function and noise power spectrum.

b. Compare the restored image with the original foggy one. Comment on the level of detail recovered and discuss any limitations of the method in this context.

5 Analytical Questions

Textbook Questions

Please provide the solutions to the questions presented in the 5th chapter of the Image Processing book (Edition3): 1, 13, 23 and 25.
Extra point: 29 and 32.