بسم الله الرحمن الرحیم

University of Tehran
College of Engineering

Digital Image Processing

Instructor: Dr. Hamid Soltanian-Zadeh

Homework Assignment 6:

Wavelets and Multiresolution Processing - Image Compression

Due date: 1404/02/15

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Contents

1 Instructions

Please answer the following questions based on Chapter 7-8 (*Wavelets and Multiresolution Processing - Image Compression*) 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	1404/02/15- 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-HW6-810199034`*). 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 Wavelet-Based Image Decomposition

Background

Wavelet decomposition allows us to analyze an image at multiple scales. This is especially useful for tasks like compression, enhancement, and noise removal. In this exercise, you'll explore 2D wavelet decomposition and interpret the result.

a) Perform one-level 2D Haar wavelet decomposition on the provided image.

b) Visualize all four subbands (LL, LH, HL, HH).

c) Describe what type of information each subband holds.

d) Discuss the effect of increasing the level of decomposition to 2 or 3.

3 Wavelets in Denoising

Background

Wavelets can be used to effectively denoise images by thresholding high-frequency coefficients. This exercise explores that process and compares it to standard spatial filtering.

a) Add Gaussian noise ($\sigma = 20$) to the image.

b) Apply wavelet denoising using soft-thresholding on the high-frequency bands.

c) Compare with Gaussian smoothing in spatial domain.

d) Compute PSNR for both methods and discuss which preserved more details.

4 Multiresolution Edge Detection

Background

Edges detected at multiple resolutions can help identify features at various scales, especially useful in complex scenes. This task investigates how wavelets assist in this process.

a) Perform wavelet transform on the given image (2 levels).

b) Use the LH, HL, HH bands to extract edge information at each scale.

c) Reconstruct an edge map combining detail bands.

d) Compare with standard Sobel edge detection.

5 Image Compression via Predictive Coding

Background

Compression reduces the amount of data needed to represent an image by removing redundancy. Predictive coding is a fundamental technique that uses previously known pixel values to predict the next pixel, storing only the prediction error. This exercise focuses on basic predictive compression concepts.

a) Perform first-order predictive coding (using the left neighbor pixel as predictor) on the given image (of q2).

b) Calculate and plot the histogram of prediction errors.

c) Discuss how the entropy of the prediction error compares to the entropy of the original image.

d) Apply a simple lossless Huffman coding to the prediction errors and estimate the compression ratio.

Textbook Questions

Please provide the solutions to the questions presented in the 7-8th chapter of the Image Processing book (Edition3): 1 and 4 of chapter 7 — 9 and 13 of chapter 8