University of Tehran

School of Electrical and Computer Engineering

Digital Image Processing

Instructor: Hamid Soltanian-Zadeh

Assignment 6

Chapter 7 – Wavelets and Multiresolution Processing

Chapter 8 – Image Compression

Due Date: 11th of Ordibehesht 1401

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Problem 1

In this problem, you will experiment with the 2D Haar Wavelet Transform.

a. Implement the forward 2D Haar Discrete Wavelet Transform using 1D, non-standard, Discrete Haar Wavelet decompositions. Use the normalized filters shown below and illustrate the results of the forward (i.e., wavelet coefficients) on the "house.tif" and "fruits.tif" images, using the convention presented in the class.

Low Pass: $\frac{1}{\sqrt{2}}[1,1]$ High Pass: $\frac{1}{\sqrt{2}}[1,-1]$

b. Implement the inverse 2D Haar Discrete Wavelet Transform. Keep in mind that the inverse Haar wavelet transform uses the same masks. Using the wavelet coefficients from section a, reconstruct the "house.tif" and "fruits.tif" images. Show the reconstructed images and report the reconstruction error (i.e., MSE error between the original and reconstructed images).

$$MSE = \frac{1}{M.N}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}\left[f_{original}(x,y) - f_{reconstructed}(x,y)\right]^2$$

Note: In this part you should reconstruct the original image perfectly so pay attention to convolution, zero padding, and up-sampling. **<u>MSE must be zero in this part</u>**.

c. Reconstruct each image using the 5%, 40%, and 95% largest coefficients (in terms of absolute value) of the discrete Haar wavelet transform and the 5%, 40%, and 95% largest coefficients of the discrete Fourier transform (in terms of magnitude); set all other coefficients to zero. In each case, show the reconstructed images and report the reconstruction error.

d. By setting coefficients of discrete Wavelet or discrete Fourier transform to zero in Part (c), you compressed the images as well. Save all the reconstructed images of the last part keeping different largest coefficients and compare their size to the original images. Compare the compression ratios too. Which of the transforms (DFT or DWT) outperform the other for image compression?

Note: You are **not allowed** to use MATLAB built-in functions for **wavelet transform** in this problem (e.g., dwt2, idwt2, etc.).

Problem 2

Consider "parrots_noisy.tif":

a. De-noise the image using a Haar-based DWT by using "dwt2" function and applying three different thresholds on horizontal, vertical, and diagonal detail parts. Then, reconstruct the image using "idwt2" function.

b. Repeat the above procedure by "db5" and "sym20" wavelets. Compare and discuss the results of the three wavelets.

c. De-noise the image using DFT and then compare the results with DWT and describe intuitively which result is superior in what kind of noises.

d. Use the MATLAB toolbox "waveletAnalyzer" to denoise the image and explain all the steps of your work. You can type "waveletAnalyzer" in MATLAB command window and click on the "Wavelet 2-D" button, then you can load your image and calculate discrete wavelet transform using the commands.

Problem 3

Write a function, "insert_watermark", which takes two square images of equal size, an input image and a watermark, as arguments and mode (visible or invisible), and returns watermarked image. Use your function to watermark an image of your choice with a watermark of your choice and explain your work in your report. In invisible watermarking you have to extract watermark from watermarked image to evaluate your function.

Hint: To achieve a good result in this problem, you can download a logo image form the web.

Problem 4

In this problem, you will learn to remove coding redundancy by using "Huffman coding".

a. First calculate probability for each intensity in "mountain.tif". How many bits is needed to store original image?

b. Now encode each intensity value and report average length of this code. How many bits is needed to store this code? Compare the total bits to part b.

c. Calculate entropy of original image by using equation 8.1-7 from the textbook. Compare this entropy to the average length of encoded image.

Note: You are **only allowed** to use MATLAB built-in functions for part b.

Descriptive Assignments

Please solve the following questions of the textbook:

Problems 1, 8, 19, 25, and 35 of Chapter 8

Notes:

1. Put written codes for each problem in one m-file, and for each section, intercept them by %%.

2. Analytical problems can be solved on papers, and there is no need to type the answers. The only thing that matters is the quality of your pictures. Scanning your answer sheets is recommended. If you are using your smartphones, you may use apps such as CamScanner or Google Drive Application.

3. Simulation problems need report as well as source code and results. This report must be prepared as a standard scientific report.

4. Your report is particularly important in the correction process. Please mention all the notes and assumptions you made for solving problems in your report.

5. You have to prepare your final report, including the analytical problems answer sheets and your simulation report in a single pdf file.

6. Finalized report and your source codes must be uploaded to the course page as a ".zip" or ".rar" file with the file name format as:

Fullname_StudentNumber_HW#.rar

7. Plagiarisms will be strictly penalized.

8. You may ask your questions from the corresponding TA of each assignment.